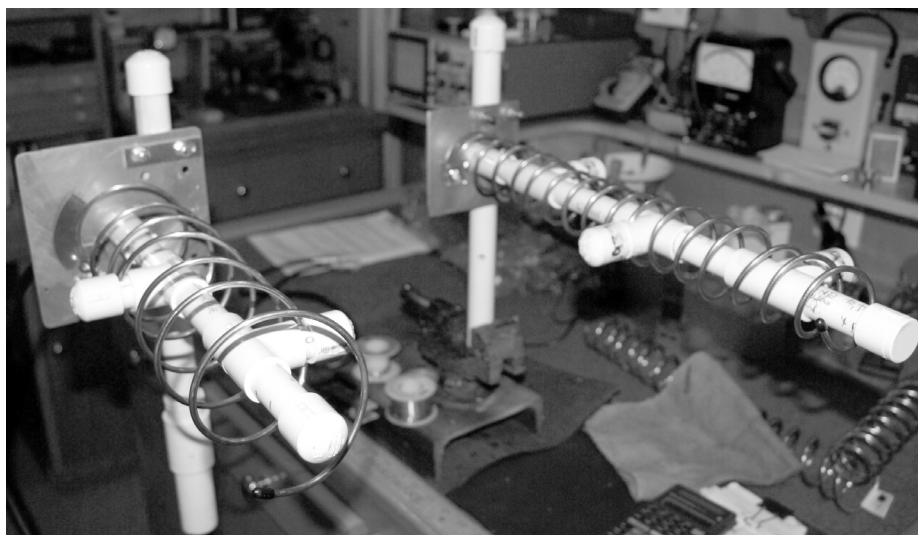
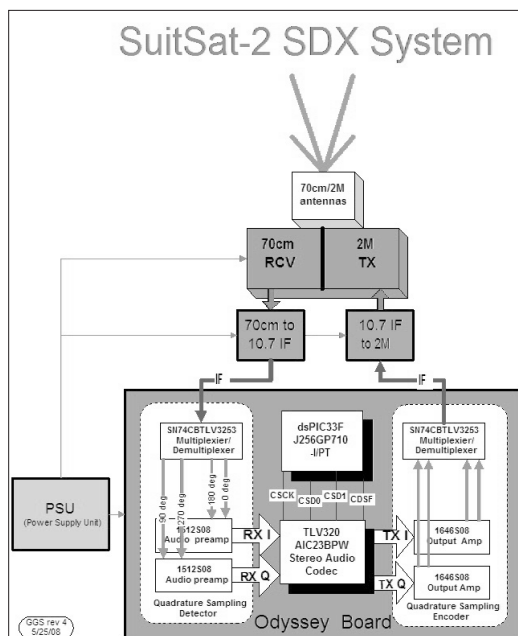




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Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

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AMSAT Announcements

2008 AMSAT Annual Meeting and Symposium

"The 2008 Harry Yoneda, JA1ANG (SK), AMSAT Space Symposium" will be held October 24-26, 2008 in Atlanta (Buckhead), GA. The AMSAT BOD meeting preceeds the Symposium. This is a family friendly location in the exciting Buckhead area of Atlanta. Only 1.5 blocks to the best shopping in Atlanta and to the MARTA subway system. You can even ride MARTA from the airport. Nicely appointed rooms at the Atlanta Buckhead Doubletree Hotel. Information can be found at <http://www.amsat.org/amsat-new/symposium/2008/index.php>. There will be a Sunday trip to the Georgia Aquarium, the world's largest aquarium. Watch in awe as the huge whale sharks glide through the tank. Plan on being there!

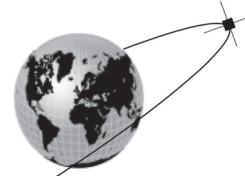
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

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AMSAT's Eagle Project

In 2004, AMSAT's leadership presented the membership with new mission and vision statements. The vision statement begins, "Our Vision is to deploy high earth orbit satellite systems ..." Since then our engineering department with guidance from the AMSAT board and the executive team have worked to define a mission that would fulfill this vision and get it implemented. The result is the Eagle project. While I recognize that not everyone uses the term "Eagle" to mean the same thing, when I refer to the Eagle project I mean the totality of our efforts to get a high orbit satellite launched, regardless of its ultimate configuration and whether it is a standalone or rideshare satellite.

Since the first article on a suitable satellite design was published by Dick Jansson, KD1K, (ex WD4FAB), at the 2000 AMSAT Symposium, a number of developments have taken place. Key Eagle technical meetings were held in 2001 (Denver), 2002 (Orlando), 2004 (Orlando), 2005 (Pittsburgh) and in 2006 (San Diego). Other smaller focus group meetings have been held during the past four years, and many monthly reviews have been conducted via teleconference. Each meeting refined and clarified AMSAT's plan for the Eagle mission and provided more design details. The results of this evolution have been documented for the membership in many *AMSAT Journal* articles over the years.

Over time Dick's original 60cm cube with fold-out solar panels had its height reduced and then was changed from four to six sides to improve its spin stability and add more solar power generation capability.

Two primary transponder payloads have been defined. A linear transponder with U and L band uplinks and V and S1 band downlinks is intended to provide the traditional and popular communications modes. A new digital transponder, the Advanced Communications Payload, is intended to provide a modern high performance all-mode communications transponder on S2 and C bands to serve a new class of user wanting good long range communications with as little as a two foot dish, similar to a modern TVRO dish. Recently AMSAT began design work on a matching ground station for the ACP.

A new opportunity presented itself in the Summer of 2007 when AMSAT began

talks with Intelsat General Corporation and later with Intelsat (the international parent company) about possible rideshare or assisted launch opportunities. A rideshare launch is particularly interesting, as it would allow the Eagle satellite to be downsized and attached permanently to a commercial satellite in a geostationary orbit. The downsizing would result from the lack of need for independent solar power generation, propulsion or orbit stabilization subsystem for Eagle. The antenna design also becomes simpler as the satellite would be on a stable platform with a fixed orientation relative to the Earth. Discussions with Intelsat continue, but it has become clear that this opportunity is not going to be available at a discounted price so we must find a funding source or other leverage before we can make much more progress. In the mean time AMSAT will continue design work on multiple Eagle structures suitable for either an independent elliptical orbit or for a rideshare opportunity. Believe me, we are trying to get a launch for the Eagle project. It has evolved significantly over the past few years and we were overly optimistic on setting target dates, but the vision lives on. We are all disappointed that this has not moved more quickly. There is a small army of dedicated volunteers working on subsystems like ACP, ground station, mechanical/thermal, IHU and others. These people deserve your support and encouragement. AMSAT is always in need of new people to join these development teams to add new capabilities, replace people who move on to other activities and to enhance our capacity to produce results sooner.

The most significant issue is the same as it has been for over five years when my predecessor, past president Robin Haighton, VE3FRH, announced after a fact finding trip that there are no more free launches. That has not changed, but there are plenty of launch opportunities for GTO, other elliptical orbit and geosynchronous orbits. Getting a ride takes large amounts of money or some other reason for a launch agency to carry us aloft. AMSAT-DL is facing a similar difficult situation trying to find a ride for P3E. AMSAT is continuing to investigate all possibilities and so is keeping open

continued on page 7 ...



A Satellite Dish for the 2.4 GHz Downlink

by Peter Carr, WW3O, wb3bqo@localnet.com

Several years ago I put together a BBQ grill antenna with a block downconverter for the S-band downlink of AO-40. While the reflector was a "section" parabolic it had very poor performance. It sat in the basement along with the power inserter until last month when it surfaced.

The key to better performance would be to use a true parabolic reflector. A search of the Web came up with the JR Miller Web page that sold a selection of parabolic reflectors with or without mounting hardware. Mr. Miller resides in merry old England so I worried about shipping costs and damage. I had settled on a 60 cm dish that was about \$85 in US funds. Payment was through PayPal™ and the transaction was arranged. The dish arrived in perfect condition in three days time, which is amazing.

After unpacking the reflector I set about finding the focal point. It turned out to be about 220 mm or 8.5 inches. The AIDC-3733 dipole/downconverter was longer than that so I trimmed the housing to length. I used two pieces of right angle aluminum bracket with 8-32 screws to form a base for the downconverter.

Once the downconverter was mounted to the center of the dish, I drilled four holes for the mounting bracket. Again, I used a piece

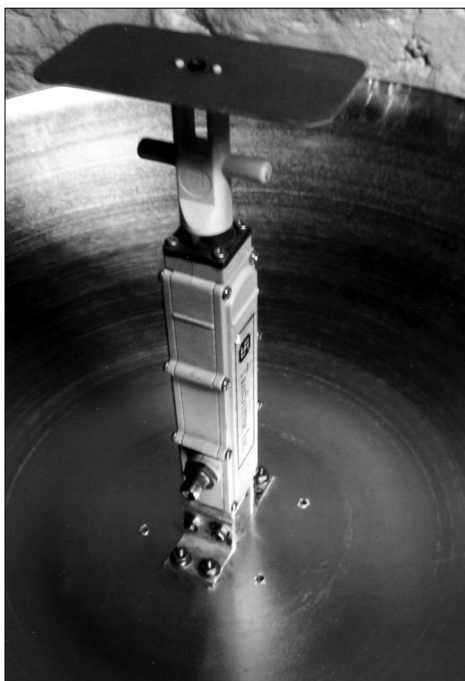


Photo 1: Detail of the AIDC-3733 Downconverter mounted to the 60 cm reflector dish. Focal length is 220 mm or 8.5 inches.

of aluminum right angle bracket with holes drilled in the corners of one face. The screws holding the electronics and the curve of the dish required that I use spacers under these corners to provide clearance. I then drilled the other face of the bracket for two TV mast clamps. Once the mounting holes were finished, I used 8-32 screws with locking nuts to attach the rear mount.

The downconverter used cable TV coax of the RG-6 variety. The RF connector on the unit will mate with either RG-6 or RG-59 coaxial connectors. I used a weather boot over the connector and filled it with silicon grease to keep water out.

I drilled two holes at the rim of the dish and used fishing line to tie the coax to the rim. The downconverter is aligned so that the coax exits downward which should reduce ice loading of the mechanics.

The satellite antenna system is located on the top of a 40-foot telephone pole. Actual pole height is about 35 feet with five feet in the ground for stability. The pole has an enclosure at the top where a 70 cm downconverter and 12-volt power terminal strip are installed. The power inserter for the dish was connected to the strip and coax was routed to the dish and down into the shack.

The converted frequency of the dish system is ≈ 145.200 MHz. The electronics are all 75 ohm impedance so there is a mismatch at the radio. With 80 feet of downlink cable the signal loss would be about 3.5 dB at 75 ohms plus the mismatch loss. I decided to try the system and get a set of performance figures before making changes. I mounted the dish on the antenna array and installed the coax into the shack.

Several years ago I wrote an article for *The AMSAT Journal* about building a 2.4 GHz signal source. That unit was used to test the old BBQ grill antenna.

The signal source is a circuit board that fits

nice onto the back side of a AA four cell battery holder. I installed a new set of AA cells and placed to source on the back porch railing. The output frequency is very close to 2.4 GHz, which would be converted to 144.00 MHz at the radio.



Photo 2: The 60 cm dish with downconverter. Note the RF output connector for use with a cable TV coax connector.

The radio I used is an old Yaesu FT-290 all-mode rig that has done very well in 10+ years of satellite use. I dialed in the downconverter output frequency, opened the squelch and

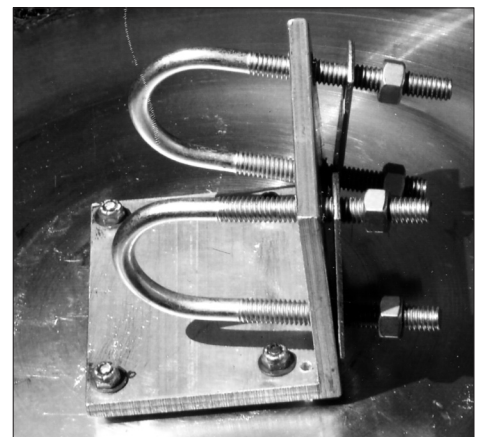


Photo 3: The rear mounted aluminum angle bracket with two TV mast clamps.

rotated the antenna toward the signal source. Sure enough, there was the blank carrier. I then tested the resolution of the antenna by swinging the array either side and above and below the peak signal. These are TV antenna rotators, which have really coarse resolution. The results were a reduction to half signal amplitude on the S-meter for two steps in azimuth on both sides and about three steps

above and below the peak. In operation on AO-51 the beam width in both axis was considerably smaller.

At the end of April I e-mailed Drew, KO4MA, of the AO-51 Control Team to inquire if there were plans to place the satellite in the V/S mode of operation. He replied that it would be considered. When the May schedule was posted to the AMSAT Web site there were four days of V/S mode. I now had a satellite signal for testing.

My *InstantTrack* computer program seems to be slightly early for the actual AOS. The computer's system time is set using the NIST utility and the Keps are refreshed about every ten days. That said the satellite appears about 2 minutes late on the correct azimuth at AOS and elevation angle for my horizon of about +3 degrees. At slant ranges of about 1900 km I can hear periodic quieting of the noise as I tune from 145.230 downward to 145.200 MHz (Doppler shift). Voice signals don't appear until the range drops to about 1200 km. During signal fade the drop in RF is much sharper than on 70 cm. This may be due to the "horizontal" polarization of the dish. I'm looking forward to trying a helix in place of the dipole for comparison. Also, the dish must be aimed right at the bird. The TV antenna rotators have a difficult time pointing that accurately. I find it easier to "lead" the bird and allow it to fly into the antenna's beam width.

A 2m preamp would overcome the 3.5 dB cable loss of the system. I plan to install Advanced Receiver Research preamp model P144VDA in the enclosure at the top of the pole right after the power inserter. The goal is to improve the signal to noise ratio at the radio and possibly reduce some of the fading.

I would like to thank Drew and the entire AO-51 Control Team for giving me to chance to test my system under actual conditions. It has been an incredible learning experience.

Resources

Reflector; www.jrmiller.demon.co.uk/products

AIDC-3733; members.aol.com/k5gna/aide3733modifications.doc

www.members.cox.net/nx7u/ao40.htm

www.homepages.ihug.co.nz/~jps1/powering_remote_units1.htm

Preamplifier; www.advancedreceiver.com



Photo 4: The completed dish mounted on the station satellite array. The power inserter is located in the enclosure below the bottom rotator.



Photo 5: The 2.4 GHz signal source used to test the dish. The circuit board is attached to the battery box with Velcro.



A Radio Amateur's Solution for the Attitude Determination of PolySat CP4 (2.1) Using Telemetered Magnetometer Data.

Colin Hurst, VK5HI, cjhurst@bigpond.net.au

Editor's Note: Due to the length of this article and the number of included graphs and plots, this paper will be published in two parts. The second part will be published in the next issue. Apologies for this.

Introduction

I have been interested in the attitude parameter of Amateur Radio satellites for many years. The launch of PolySat CP4 (2.1) was of particular interest in that this Cubesat satellite incorporated multi-axis magnetometers (refer to Appendix A) [In the next issue. – Ed.]. Whole orbit telemetry provided by the CalPoly Team and telemetry that I downloaded from CP4 while over Australia, was analysed in the first instance using solar panel currents and temperatures.

Using a wooden model and the solar panel currents, a number of ad hoc conclusions were drawn, the most logical being that CP4 was rotating about the Y-Y axis with the +Y axis (antenna) earth pointing. With any satellite it is highly desirable to maintain the antenna earth pointing, which in the case of CP4, is the +Y face.

The challenge was to confirm this using the telemetered magnetometer data. My interpretation of the magnetometer data was initially flawed. Information provided by Mr. Jake Dimiceli, highlighted the approach CalPoly uses to determine the attitude of CP4. This document outlines an approach based on that advice.

Conclusions

The results indicate that CP4 has the +Y axis earth pointing while in the northern hemisphere and vice-versa in the southern hemisphere. Rotation around the Y-Y axis is 2.07 rpm based on 29 second sampling.

Methodology

To process the magnetometer data I downloaded the World Magnetic Model WMM-2005 from the National Geophysical Data Center. Information may be found at: <http://www.ngdc.noaa.gov/seg/WMM/DoDWMM.shtml>.

Subsequently I produced a program incorporating the source code for WMM-2005 and the Plan13 Orbital Determination program by James Miller, G3RUH. The program takes as its source a timestamp generated from the telemetered data from

CP4. The source file is processed by Plan13 to return the sub-satellite orbital points of latitude and longitude and the orbital height, which are passed to the geomagnetic model. The output is a comma-delimited file (.csv) containing the input parameters and the F, X, Y, and Z components of the earth's magnetic field plus the declination D. (refer to Appendix B) [In the next issue. – Ed.].

The data included in the .csv file is pasted into an MS Excel Spreadsheet containing the telemetered data. A macro processes the data as follows:

The earth's and CP4's X and Y magnetic field components are referenced to the earth's magnetic X-axis, and then corrected to true north. CP4's X-axis relative to true north is labeled as **phi** on the included graphs. The angle subtended by the Z-axis relative to the X-Y plane is calculated and is labeled as **theta** on the included graphs. **Theta** = 0 degrees equates to the +Z axis being earth pointing.

Ascertaining the rotational angle **phi** relative to X true north for each telemetered frame and storing the incremental difference in an array allows calculation of the spin rate. The array is scanned and filtered to derive the best fit. (Refer to Appendix D) [In the next issue. – Ed.].

The process outlined above applies to satellites that have their antenna mounted on the +Z face, with the objective of maintaining the +Z face earth pointing for optimal communication. If the satellite only has passive magnetic stabilization, the +Z face will only be earth pointing in one of the earth's hemispheres.

In the case of CP4 the antenna is mounted on the +Y face, hence the desire to maintain the +Y face earth pointing. The processing I performed on the telemetered values from CP4 involved two sets of criteria, the process outlined above and one where the Y-axis and Z-axis were transposed.

Methodology Accuracy

Magnetometer Accuracy

The telemetered values for the respective magnetometer axes reveal differing values. CP4 has dual axis (A & B) magnetometers mounted on 5 faces of the satellite.

X pointing magnetometers are 5A and B7.

The -X pointing magnetometer is B9.

-Y pointing magnetometers are A6, A7, A8 and A9.

Z point magnetometers are B5 and B6.

The -Z pointing magnetometer is B8.

Hence: X = A5, B7, -B9.

Y = -A6, -A7, -A8, -A9.

Z = B5, B6, -B8

Refer to Figure 11 [In next issue - Ed.] for the magnetometer layout.

The approach finally used was to apply the averaged values for all axes. The averaged values and the variation in telemetered values are highlighted in Figures 7, 8 and 9 [In next issue - Ed.]. These graphs have been compiled using a database of data downloaded by N6CP and that of radio amateurs worldwide, including my own. Note: This database includes frames telemetered at 5 minute, 2 minute and 30 second intervals.

Prior to settling on the averaged values, combinations of the telemetered values $F(\text{CP4}) = \text{SQRT}(X^2 + Y^2 + Z^2)$ were compared to the earth's total magnetic field (F), recognizing that the two magnitudes should be equal (Refer Appendix B). However, no combination appeared to be better than the averaging approach, albeit a linearity issue was noted (below).

Magnetometer Linearity

The analytical process highlighted a linearity issue. As part of the analysis the magnitude of each set of telemetered X, Y and Z flux values was referenced to the total flux (F) obtained from the World Magnetic Model and an error ratio calculated. This error ratio was used to produce an alternative solution. A review of the various parameters suggests that the nonlinearity is directly proportional to the magnitude of the earth's magnetic field (F). Averaging macros were applied to the respective values of error ratio and the flux quantity F (earth's total magnetic flux). Refer to the respective Figures 5, 6a and 6b detailing the results.

Keplerian Elements

The correct daily Keplerian element set was used for each whole orbit data period analysed.

Assumptions

- Based on the preliminary analysis using the solar panel currents that CP4

is rotating about the Y-Y axis, two different solutions were calculated to ascertain whether it is +Z or +Y earth pointing.

- The telemetered RTC (real time clock) time has been assumed to be UTC – 7 hours.
- The telemetered RTC times are correct. (Some results suggest otherwise).
- Advice from the Polysat team indicated that CP4 did not have passive magnetic stabilization, but did have a number of magnetorquer units in the side panels, but they were not operational.

Results

- I have been able to analyze whole orbit dumps downloaded by N6CP for 24th May, 12th June and 21st June 2007, as well as small samples downloaded while CP4 was over Australia.
- The results confirm that CP4 is rotating about the Y-Y axis. Results examining a spin solution around the Z-Z axis highlight potentially erratic and unstable performance, if that indeed was the case. (Comparisons of Figures 1 and 3).
- The results tend to suggest that there is a level of magnetorquing taking place. This is characterized by the “squarish” symmetry of the **theta** curve shown in Figure 1. The attitude profile does not follow a passive magnetic stabilization profile eg: “sinewave-ish”.
- The resultant attitude of CP4 using the magnetometer data, specifically while orbiting over Australia, tends to confirm the pattern of download performance I observed viz: variable strength signals and antenna shielding. Although the pattern was not categorical, there was an emerging trend. The beaconing of telemetry at 1-minute intervals of 2-minute samples provided excellent recordings from which to analyze. Refer to Appendix C [In next issue. - Ed.] for a detailed explanation of two such passes.
- Speed calculation 24th May
Avg Rotation (degrees) / Time Inc (seconds)*60/360 (revs per minute)
 $359.41 / 119 * 60 / 360 = 0.503 \text{ rpm}$ (1 minute 59 second sampling)
- Speed calculation 12th June
 $360.33 / 29 * 60 / 360 = 2.070 \text{ rpm}$ (29 second sampling)
- Speed calculation 21st June

$360.19 / 29 * 60 / 360 = 2.070 \text{ rpm}$ (29 second sampling)

- The attached charts are an overview of the analysis conducted.

Figure 1: +Y pointing solution, error ratio correction

phi represents alignment of X-X axis relative to true north

theta is the Y-Y (or Z-Z) axis relative to the X-Y geomagnetic plane

Slat is the satellite sub-orbital latitude point.

Figure 2: +Y pointing solution, no error ratio correction

Figure 3: +Z pointing solution, error ratio correction

Figure 4: +Z pointing solution, no error ratio correction

Figure 5: Error correlation, error ratio and total flux F vs. sequence number

Figure 6: Error correlation, total flux F vs. error and error vs. total flux F

Figure 7: +X-axis – flux data

Figure 8: +Y-axis – flux data

Figure 9: +Z-axis – flux data

Figure 10: Speed distribution profiles.

Figure 11: Magnetometer layout and World Magnetic Map Axes.

Appendix A: Polysat CP4 Magnetometer Information.

Appendix B: Using the World Magnetic Model WMM-2005 (Figure 12). [In next issue - Ed.]

Appendix C: Confirmation of Attitude by Observation (Figure 13). [In next issue - Ed.]

Appendix D: Explanation of Rotational Speed Derivation

Acknowledgements

The assistance of CalPoly Team Members, Messrs Keith McCabe, Bryan Klofas, Carvey Cowgill and Jake Dimiceli in providing information to allow detailed analysis is greatly appreciated.

National Geophysical Data Center: World Magnetic Model WMM-2005.

James Miller, G3RUH: Plan 13 Orbital Program.

Jan King, VK4GEY/W3GEY, and Terry McCarthy, VK5GU, for their comment and reviews while preparing this document. 🌐

Figures begin on page 24 ...

Apogee View

... continued from page 3



the engineering efforts to build multiple spacecraft configurations, with as much commonality as possible, so we will be ready for the next opportunity when it is identified.

Thank you all for your continuing support and please feel free to contact me or any other AMSAT board member or officer through the links on the AMSAT Web page (www.amsat.org, go to “About AMSAT” then “Our Leadership Team”). We are ready to answer questions and exchange ideas with members any time.

73,

Richard M. Hambly, W2GPS

AMSAT President 🌐

The AMSAT Store should be back online soon! Here are some more AMSAT products.

AMSAT 10' locking carpenter's tape \$5



AMSAT offers a 2GB Flash Drive with the AMSAT logo and a neck lanyard. Save your stuff and show your support for AMSAT. \$20 + Shipping (limited supply)



AMSAT at Dayton 2008

Gould Smith, WA4SXM, wa4sxm@amsat.org

AMSAT had a large presence at the 2008 Dayton Hamvention. We occupied the entire row of six booth spaces. We had the standard four booth spaces for publications, apparel, software, memberships and hardware plus two booth spaces to showcase AMSAT engineering developments. The booth is centrally located directly across from the ARRL Expo and only about 50 yards from our outdoor satellite demonstration area.

The weather was wonderful all three days and the Hamvention attracted around 18,000 people. The fun actually started on

Suds gathering at Marion's Piazza. Good times and good food were enjoyed by all.

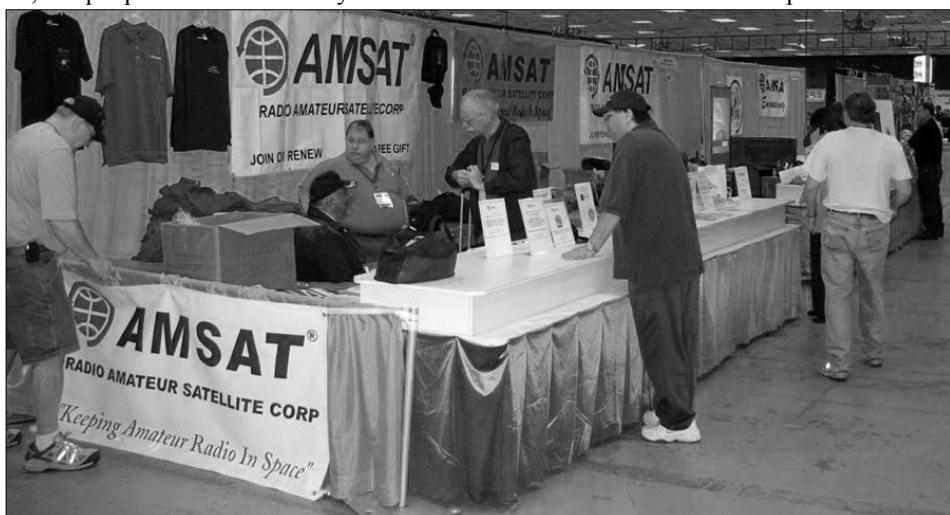
Friday morning saw a slightly different schedule than past years, the inside area was open 9-6 rather than 8-5. The extra hour was welcome by the booth opening team who got the booth ready to go, the outside satellite demonstration area setup and the Engineering team members ready to talk about their projects. We had a surprise donation on Friday morning. Mitch, VE6JTM, of Alfa Radio Ltd, in Edmonton, Alberta donated an Alfa Spid Az/El rotor

AMSAT Engineering Area

This year we had two carpeted booth spaces for AMSAT Engineering to show off their projects and discuss them with members. On display and visible in the photograph of the Engineering area (lower left clockwise) are: CubeSat from Cal Poly, P3D protective cover with 'REMOVE BEFORE FLIGHT' ribbon, 1/2 scale Eagle model, full scale Eagle core with sample modules attached, framed photograph of the Kodak #77 Daytona Prototype car with the AMSAT logo and Web site, operational SuitSat-2 SDX unit with a video module.

The Engineering area was staffed by Michelle Thompson, W5NYV, [ACP ground station]; Matt Ettus, N2MJL, [ACP satellite module]; Tom Clark, K3IO, [SuitSat SDX]; Barry Baines, WD4ASW, [Eagle]; Lou McFadin, W5DID, [SuitSat]; Phil Karn, KA9Q, [communication software] and Rick Hambly, W2GPS, [all projects] during all three days. There was a projector between the regular booth and the Engineering area showing photographs of the AMSAT lab in Pokomoke, MD. Bob Davis, KF4KSS, was unable to attend, but sent the Eagle model and core model to show the type of aluminum material that the center part of the Eagle satellite will be built from and how the modules will attach to this core.

Mike Young brought along his LVB Tracker demonstration unit connected to one of the computers running the SatPC32 program



The AMSAT booth is ready for business! Shown in the photo are from left to right: WB8CXO, N3YDT, NB2F, K3PER, KC9RAN and WA4SXM.

Wednesday afternoon when Joe Prokop, KC8RAN, and Chuck Pinkham, K3PER, picked up over twenty boxes that we had shipped to Nancy Makley, KC8GYW, to store before Hamvention. We had a great group of volunteers to help setup the booth on Thursday afternoon. The new booths necessitated a different arrangement, but this quickly came together with the new layout plan. We had new AMSAT banners made for the main part of the booth and the new Engineering area.

Thanks to Barry Baines, WD4ASW; Steve Belter, N9IP; Alan Biddle, WA4SCA; Mark Hammond, N8MH; Dee Interdonato, NB2F; Roger Ley, WA9PZL; Chuck Pinkham, K3PER; Joe Prokop, KC9RAN; Keith Pugh, W5IU; Jim Randall, N3YDT; Walt Wittenberg, K0CEH; Mike Young, WB8CXO, and Martha who not only helped set up the booth on Thursday, but worked much of the Hamvention in the booth or demonstration area.

After setup the crew headed to the Pizza n'

with a control box for us to raffle off. Nick Lauerman, KB9WWS, won the rotor in a drawing on Saturday afternoon.



The AMSAT Engineering area.



Frank Brickle, AB2KT, talking with Michelle Thompson, W5NYV, in the engineering area of the AMSAT booth.

and tracking all active amateur satellites over Dayton in real time. Mike has ordered parts, soldered parts, made cables, assembled everything into the enclosures and tested over 100 LVB Tracker boxes. He brought over thirty boxes to Hamvention and we sold them all. This has been a total volunteer effort on his part – Thank You Mike. All of the LVB Tracker documentation can be found at <http://www.LVBTracker.com>. We are caught up with current orders so if you are interested in ordering a box, please contact Martha. We have high hopes that the AMSAT store will soon be operational and you may order there.

Satellite Demonstrations

The Hamvention again provided AMSAT with a cordoned off area in which to conduct live satellite demonstrations. This area is only about 50 yards from the AMSAT booth and right in front of the Ball Arena entrance. Keith Pugh, W5IU, demonstrated how easy it is to operate both FM and SSB satellites using a small portable radio and a homemade WA5VJB antenna. Mark Hammond, Roger Ley and Keith Prokop assisted with the demonstrations,

questions and explanations. The great weather and lively demonstrations dazzled many observers and created interest in trying amateur satellite operation.

Steve Belter recorded Keith during a high AO-51 pass on Sunday morning. This video is available at the following Web site for viewing in Windows Media format.

Operating AO-51 Video

mms://media.wmfd.com/amsat/W5IU_AO51_Dayton_Demo.wmv

AMSAT/TAPR Banquet

Due to retirements and restrictions on replacing those positions at the Air Force Museum we were unable to have the



Keith Pugh, W5IU, shows them how it's done!

joint AMSAT/TAPR Banquet again at the museum. A new location just south of Dayton was chosen, the Kohler Presidential Center. Everyone seemed to get there with no problem, but many GPS systems were seen glowing on the windshields as people left the venue. The room was nicely appointed and just the right size for the gathering. The 6:15 PM start time for the cash bar made it difficult for some to get there in time for the refreshments with Hamvention closing at 6:00 PM, but everyone was there in time for the delicious buffet at 7:00 PM.

Rick Hambly and Tom Clark presented a moving tribute to their friend Dr. Ron Parise, WA4SIR (SK). Lou McFadin and Bob Bruninga also shared remembrances of Ron.

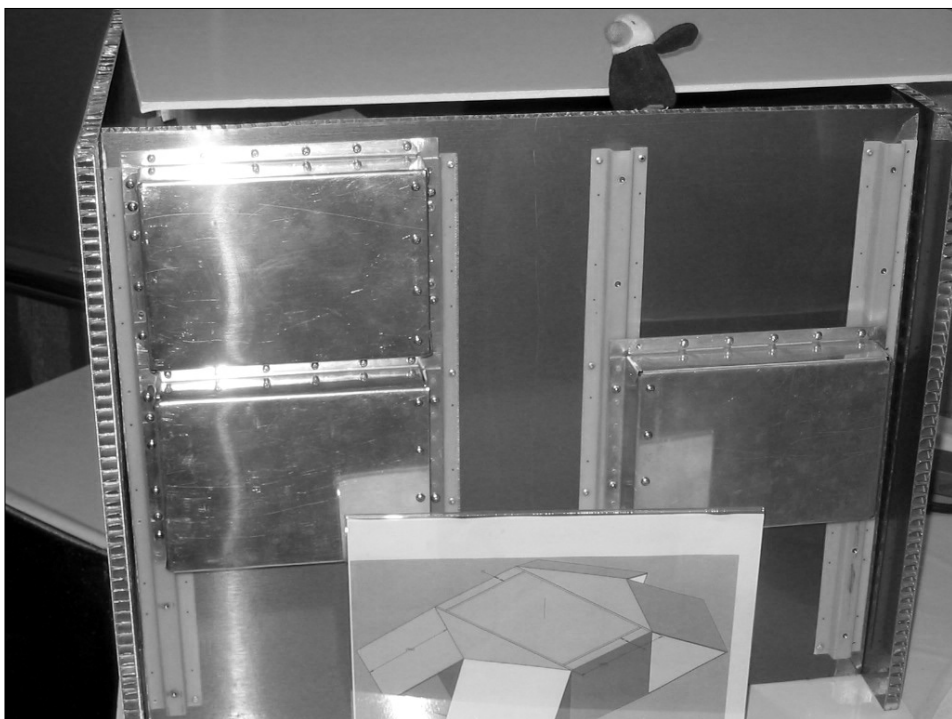
The speaker for the evening was Tony Hutchison, VK5ZAI, ARISS representative for Australia, who entertained the group with stories of his early contacts with the Shuttle and ISS crews from Australia. Tony continues to be active with the ARISS group to further the Amateur Radio presence aboard the International Space Station and provide school contacts with the astronauts/cosmonauts around the world.

Jim Simpson, WB8QZZ, DARA President and Steve Coy, K8UD, DARA Vice President were also at the Banquet and presented AMSAT with a generous \$5000 check.

AMSAT Forum

The AMSAT Forum this year was at 0900-1130 Saturday, May 17 in the newly created Forum Room 5. We had a standing room only crowd due to good attendance and the Fire Marshall allowing fewer seats than the room could easily hold.

We had a great lineup of speakers with the theme of AMSAT projects and activities



AMSAT Eagle full size core demo with some modules attached.



for 2008.

Moderator: **Barry A. Baines, WD4ASW**, AMSAT Corporate Secretary & VP-Special Projects

Rick Hambly, W2GPS, AMSAT President "AMSAT Update". Rick presented a status report on the Intelsat negotiations, a brief update on Eagle and AMSAT-DL's Phase 3-E Project. Bob Davis, KF4KSS, was unable to attend so Rick also showed the progress during the last year on AMSAT's new Integration Lab in Pocomoke, MD as well as discussed the proposed projects and Educational Institute at the lab.

Gould Smith, WA4SXM, AMSAT VP- User Services first gave an update on AMSAT Operations and accomplishments in 2008 and upcoming Field Day modes as Drew Glasbrenner, KO4MA, was unable to attend. This talk was followed by an update on AO-51, results of the winter no eclipse period and spring/summer operation until no eclipse returns in late summer.

Mark Hammond, N8MH, AMSAT Command Station, "AO-16 Update" provided an overview of how AO-16 was reconfigured as a voice repeater satellite over the winter and how the current eclipse period is affecting operation.

Michelle Thompson, W5NYV, ACP Ground Station Development Engineer, "AMSAT's Advanced Communications Package (ACP) Ground Station". ACP is designed to provide emergency communications using portable ground stations as well as make it possible for amateurs living in areas with CC&R restrictions to be able to communicate via our next generation satellite. Michelle discussed her work on the ground station component that is being developed concurrently with the satellite module. She also has created many interactive and file sharing mechanisms to solicit comment, educate and improve the design on her Namaste site, <http://www.delmarnorth.com/namaste/> or from the AMSAT Web site front page.

Matt Ettus, N2MJI, ACP System Engineer, "AMSAT's Advanced Communications Package (ACP) Space Module". Matt provided an overview of the new communications system currently under development for Eagle and a potential payload package to be placed on a commercial geostationary satellite. ACP is designed to provide emergency communications using portable ground stations using high and slow speed digital communications on our next

generation satellites. Matt explained why ACP is being developed and discussed the work his team is doing on the payload module.

Tony Hutchison, VK5ZAI, Australian ARISS coordinator filled in for Frank Bauer, "A Ham Radio Operator's View of ARISS". Tony talked about current ARISS activities aboard the ISS and some of his experiences in Australia with ARISS.

All of these talks were videotaped by Steve Belter, N9IP, and converted to Windows Media Video format by Mike Young, WB8CXO. The videos are available as streaming video in a .wmv format. There are being hosted by Gunther and Rob Meisse at the WMFD site. You can type these URLs into compatible viewers.

Videos of 2008 AMSAT Forum at Dayton

Rick, W2GPS, AMSAT, P3E, Eagle, SuitSat-2 Update:

mms://media.wmfd.com/amsat/W2GPS_2008_forum.wmv

Gould, WA4SXM, AMSAT Operations and AO-51 Update:

mms://media.wmfd.com/amsat/WA4SXM_2008_forum.wmv

Mark, N8MH, AO-16 Update:

mms://media.wmfd.com/amsat/N8MH_2008_forum.wmv

Michelle, W5NYV, ACP Ground Unit:

mms://media.wmfd.com/amsat/W5NYV_2008_forum.wmv

Matt, N2MJI, ACP Satellite Unit:

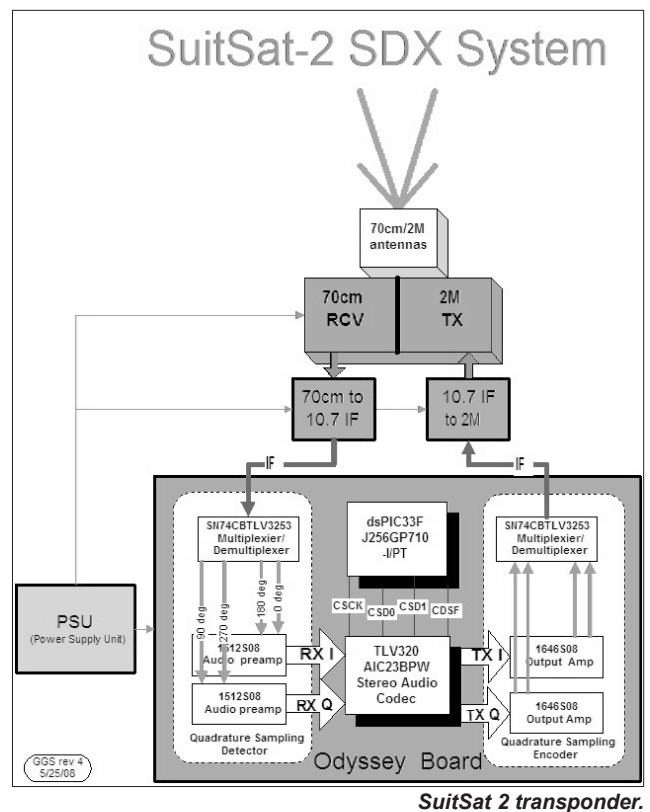
mms://media.wmfd.com/amsat/W2GPS_2008_forum.wmv

Tony, VK5ZAI, ARISS Update:

mms://media.wmfd.com/amsat/VK5ZAI_2008_forum.wmv

SuitSat-2

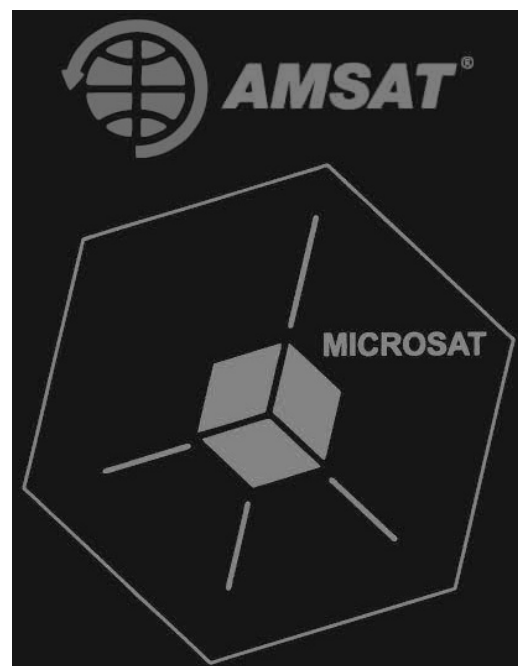
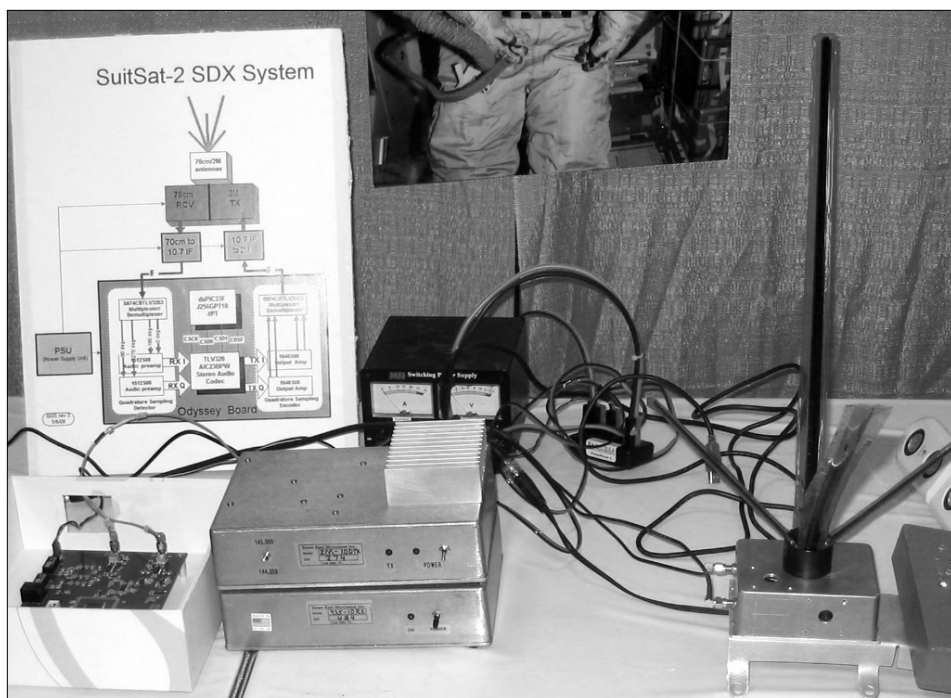
Rick Hambly and Tom Clark were able to get the SuitSat-2 SDX system working in time for Dayton. Lou McFadin, brought a working antenna system mounted to the video box. This box will house four cameras,



one on each side, one facing to the front and one facing up. Lou's demonstration unit had a camera inside that was attached to a small video display screen. The photograph of the SDX hardware shows the actual SDX board in a box on the left. Steve Bible, N7HPR, designed the SDX, Mark Raptis, KF6WTN, built the units and Tom and Rick are testing and making them operational. The three connections are for power, 70cm IF in and 2m IF out. In actual satellite demonstrations, the group outside demonstrated the SDX transponder operation in cross band repeater mode. The actual RF to IF and IF to RF modules were not available, so the DEMI modules built for testing were used in this demonstration (two boxes to the right of the SDX board). The actual RF units being developed by Ivan Gaylsh, KD4HBO, will be the same length and width as the video box seen under the antenna.

Tom Clark was the AMSAT representative at the ARRL Technology Forum on Saturday. During the forum ARRL President Joel Harrison, W5ZN, announced the League will be adding Technology as a "fifth pillar". The four other pillars embraced by the ARRL are: Public Service, Advocacy, Education and Membership.

Joel explained that "Ham radio operators, and particularly ARRL members, closely identify with current and emerging radio



SuitSat 2 SDX demo.

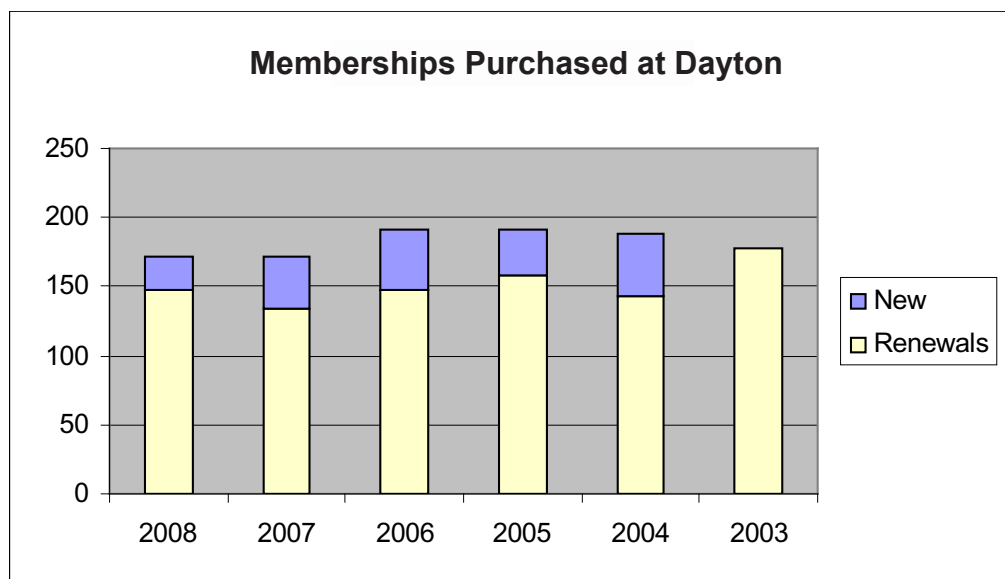
technology. Radio amateurs have entered a new era. More than a dozen Amateur Radio satellites are presently in orbit with more to come. Software is expanding the capabilities of their radio hardware and communication by digital voice and data is expanding rapidly among hams.”

We had a great group of volunteers that staffed the booth Friday, Saturday and Sunday, many of whom came back Sunday afternoon to pack up the booth and take it to our storage area. Thanks to all the setup crew who also worked the booth and Larry Brown, W7LB, Steve Meuse, N1JFU; Mike Miller, KA5SMA, Wilse Morgan, WX7P; Mal Preston; NP2L; and Paul Williamson, KB5MU. Don Agro was also at the booth on Friday and Saturday to talk with users about his MacDoppler Pro tracking software.

Dayton Summary

Good weather, good attendance and overall a good showing for AMSAT. The new Engineering area was a great success; we sold all the LVB Tracker boxes we brought.

The outside demonstrations were well received; we sold all the 2008 Getting Started books. Steve Kenwolf designed a great looking microsat logo that we put on a black tee shirt – killer item. We grossed over \$25,000 at Dayton, which is good, and the membership renewals were on par with the last few years. ☺



New AMSAT items at Dayton:

- Royal blue golf shirt with AMSAT logo \$30
- Black tee shirt with AMSAT logo and microsat logo \$15
- Black hat with AMSAT logo \$10
- DVD with 2004, 2005, 2007 Symposia papers, 2007 PowerPoints, audio and additional material \$30
- Beautiful gold and red AMSAT lapel pin \$10
- AMSAT 2GB flash drive \$25
- LVB Tracker boxes complete \$200



Helix Antenna Mathematics and Construction Techniques

John Henderson, N4NAB, n4nab@amsat.org

Introduction

With increasing interest in the higher frequencies and smaller antennas, exploring the possibilities has been very enlightening and in some cases disappointing. Considering my space limitations and neighborhood restrictions on bigger antennas, the helix design caught my attention.

There is an abundant amount of information on the Web, but I quickly found it was not all in one place and in some cases inconsistent. The construction and impedance matching techniques were varied, some good and some not so good. I was never satisfied with any of the boom/supporting techniques I found.

Over the last several months of building projects and collecting notes, this is a summary of the fundamentals of constructing a successful helix for satellite work. The photos are of a 2.4 GHz, 16-turn helix, but the principles apply to all amateur frequencies.

diameter. Following are the formulas needed to layout the helix:

Wavelength, in meters, $\lambda = 300/\text{frequency in MHz}$

Reflector, (square for ease of construction) sides should be greater than $.5\lambda$, usually $.6\lambda$ to $.75\lambda$. If the reflector is circular, calculate the diameter using the area of the square.

Circumference, C, of the helix coil = 1.00λ

Diameter of the helix, $D = C/\pi$ or about $1/3\lambda$. If you choose to support the helix wound directly on a PVC pipe, the diameter should be $.9D$

Spacing, the distance between the coils, S, is based on a helix angle, α , of 12.5° and the linear distance between the coils, $S = C(\tan \alpha)$.

There is some debate over wire size, but conventional wisdom indicates at 435 MHz and higher, diameters can range between $.006\lambda$ to $.05\lambda$.

Number of turns, N, must be greater than 3. The more turns the narrower the bandwidth and higher the gain.

The start of the first turn nearest the reflector should be spaced off a distance of approximately $S/2$.

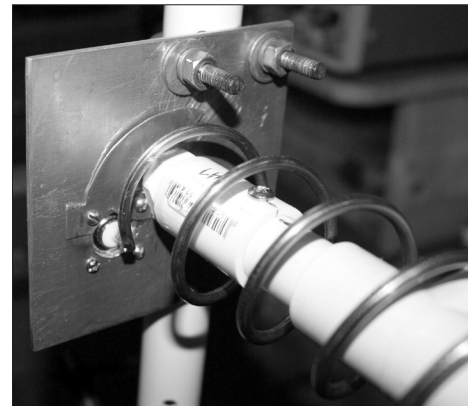
Total length of wire required, $L = NC + \frac{1}{2} \sqrt{S^2 + D^2}$

Terminal Impedance, resistive component, R, can be estimated by $R = 140C/\lambda$ and in most cases can be assumed to 140 ohms.

Estimated Gain, $G_o = (15N)/(C^2S/\lambda^3)$
Beamwidth (degrees) = $(52\lambda^{3/2})/C\sqrt{NS}$

Construction Techniques

Using the formulas you can lay out the materials needed to build the helix. The most challenging aspect of construction is how to support the helix. You will find every technique from broomsticks and Popsicle sticks to fiberglass rods. After lots of experimenting, I chose to use $\frac{1}{2}$ " diameter PVC pipe. The reflector plate is $.125$ "



Photos 2 and 3: Reflector and layout.

(3.18mm) aluminum. The coil is #6 copper ground wire.

The Helix

You must decide if you want left or right hand polarization. Looking from the reflector down the helix, typically LH polarization is defined as CCW and RH is CW. The polarization chosen determines the hole pattern in the reflector and the direction of the impedance matching strip, which will be discussed later. For 1.2 GHz helix,

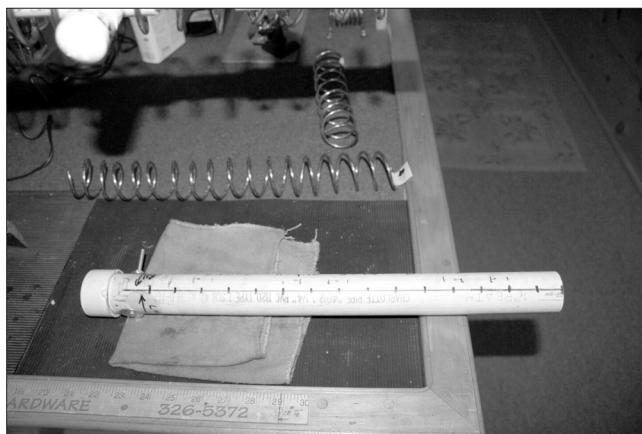


Photo 1: Coil winding jig with spacing marks.

The helix was developed in 1946, by John Kraus, a professor at Ohio State University. After listening to a visiting lecturer speak about how a helix could not be successfully used for radio work, Professor Kraus immediately went to his lab and set out to prove him wrong. He developed the principles of helix design and most of the mathematical theory of helix antennas, which are so prevalent in space applications today.

The Math

The major variables are wavelength, circumference/diameter of the helix, spacing and angle of the coils, reflector dimensions, number of turns and wire



Photo 4: The boom components.

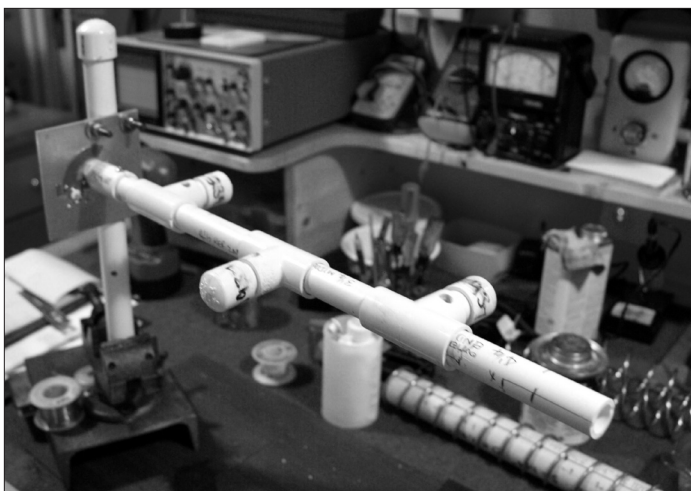


Photo 5: The completed boom.

the coil can be wound on a piece of 2-1/2" Schedule 40 PVC for a coil diameter of 2.88" (73.15mm). A 2.4 GHz helix is wound on 1-1/4" Schedule 40 PVC with a coil diameter of 1.66" (42.16mm). On the section of PVC, near one end, drill a hole through both sides, slightly larger than your chosen wire diameter. #6 copper ground wire is in the design limits and is .162" (4.11mm) diameter. See Photo 1.

Starting at this hole you can layout the spacing you calculated. Clamp one end of the length of wire in bench vise and thread the other end through the holes in the PVC. Now stretching the wire as straight and tight as possible, wind the wire up on the PVC in a tight coil until you reach the number of turns you have chosen to use. This step is where you must be aware of the RH/LH polarization. Once you determine which one you are winding, mark the direction on the pipe for future reference. Cut the excess wire and leave the coil on the tube. At this point, using the spacing marks, you can expand your helix to the correct length.

The Reflector

The reflector must be drilled for the N

indicating the helix. Then lay out the holes for the N connector (5/8" diameter and the four mounting screw holes, #4-40 screws). See Photos 2 and 3.

The boom is mounted to the reflector through a 1/2" PVC hex head pipe plug. Drill a hole for the #8-32 -1" screw through the center of the plug. Attach with the #8 screw and flat washers and two nuts. A 1/2" PVC coupling will be used later to attach the full boom to the plug.

Tuning

There are a number of impedance matching techniques. The one used here, see Photo 2, was developed by Claire Fowler, VE3NPC, and very good pictures can be found at <http://www.qsl.net/ve3cvg/antennas/2400/> courtesy of VE3CVG. The only modification was the adjustment screw to lift the copper strip closer to the helix. An #8-32 screw is used with the hole drilled and tapped in the location shown. The technique matched the helix to a 50 ohm coax at a 1:1 SWR.

With the plate completed and the N connector, tuning strip and adjustment screw installed, the boom and helix support can be constructed and mounted.

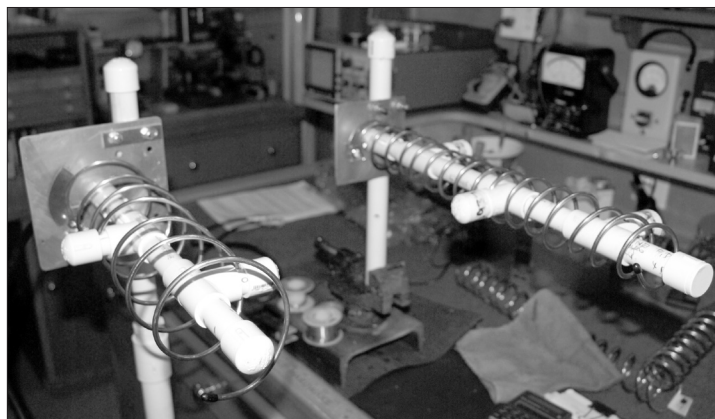


Photo 6: The completed antennas, 1.2 GHz left, 2.4 GHz right.

connector, the center support, the matching strip adjustment screw and a U-bolt for attaching to a mast. It is critical that you get the center conductor of the N connector and the adjustment screw on the circumference of the helix. The most efficient method for laying this out is to drill the center hole (for a #8-32 -1" screw) for the boom support

and scribe a circle

for the boom support

and scribe a circle

for the boom support

and scribe a circle

The Helix Support or Boom

The boom for 16 turns (see Photo 4) is made from 1/2" Schedule 40 PVC components and consists of three tees, four end caps, one slip fitting and a hex head, flat PVC pipe plug and 7 pieces of 1/2" pipe cut to the following lengths from left to right: 4",

3-1/4", 4-1/2", 2-3/8" and four 1-1/2". One of the four caps, the one on the left end piece, is not shown in the photo. The slip fitting is on the plug in Photo 4.

The holes for the helix were drilled in the tees 3/8" from the edge using a 5/16" bit. I tried drilling the holes at the 12.5° angle but found just drilling a slightly larger hole than the wire diameter was much easier. The ends caps are for weatherproofing and once the helix is installed and adjustments made, seal the holes for the wire with silicone. I found a slight bit of moisture can adversely affect the SWR.

After gluing all the pieces together (see Photo 5) mount the boom with the tees in the horizontal plane by sliding the coupling over the end of the plug. Do not glue the coupling to the plug, just slip it over the plug and drill and tap for a #8-32-1/2" screw so you can remove the boom later if need be. If you glue it you will have to cut it off to remove it.

Now carefully thread the helix onto the boom through the holes in the tees until the end of the wire on the reflector end of the helix aligns with the center pin of the N connector. Refer back to Photo 2. When the helix is aligned and symmetrical down the boom, solder the wire to the center pin and the antenna is ready for tuning.

To tune the antenna I used a Bird Model 43 Wattmeter with the appropriate element to measure forward and reflected power and a transmitting source on low power. The SWR can be adjusted by using the screw to raise or lower the copper strip. An alternative matching technique is to construct a balun, but I found the VE3NPC method very simple and effective. See the completed antennas in Photo 6.

I have templates made for the reflector and matching strip. Should you like a copy, have any questions or suggestions for improvement, please contact me, n4nab@amsat.org. I would appreciate hearing from you.

References:

ARRL Antenna Handbook, 20th Edition, Chapter 10

Antennas, 2nd Edition, John Kraus

The AMSAT Journal, July-August 1993, "Small is Best", by James Miller, G3RUH

R.C. Bandla, VE3CVG, Claire Fowler, VE3NPC, <http://www.qsl.net/ve3cvg/antennas/2400/> 



Release for AMSAT on June 15, 2008: CFC Certification 2008

On June 13, 2008 the The Office of Combined Federal Campaign Operations issued the final draft of the listings for independent organizations that have been approved for participation in the 2008 CFC. The Radio Amateur Satellite Corporation (AMSAT) was again included in the approvals.

The CFC, or Combined Federal Campaign, is the U.S. Government equivalent of the United Way in the private sector. The campaign affords all US Government employees the opportunity to make donations from their regular paychecks to CFC approved charities. AMSAT has again successfully applied to CFC for that status and is grateful for the approval. This stamp of approval means that AMSAT has met the strict standards set by the U.S. Office of Personnel Management (OPM) assuring donors that our programs of work and financial operational standards meet the standards for expectable operations and programs.

Those AMSAT supporters who wish to make payroll contributions should select the Radio Amateur Satellite Corporation (AMSAT) during their campaign this coming fall. The AMSAT CFC Charity number is 10158. Payroll deduction is a simple, convenient way to support your AMSAT.

Gunther Meisse, W8GSM
Treasurer
AMSAT North America



ATTENTION FEDERAL EMPLOYEES

AMSAT is now a member of your CFC
(Combined Federal Campaign).

When you complete your pledge for this
year's campaign, why not make a
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Satellite Corporation.

The agency number is: CFC 10158

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888-322-6728 (US)
301-589-6062

AMSAT is the North American distributor of **SatPC32**,
a tracking program designed for ham satellite applications.
For Windows 95, 98, NT, ME, 2000, XP, Vista.

Version 12.8 has improved Windows Vista compatibility and enhanced support for tuning multiple radios.

Version 12.8 Features:

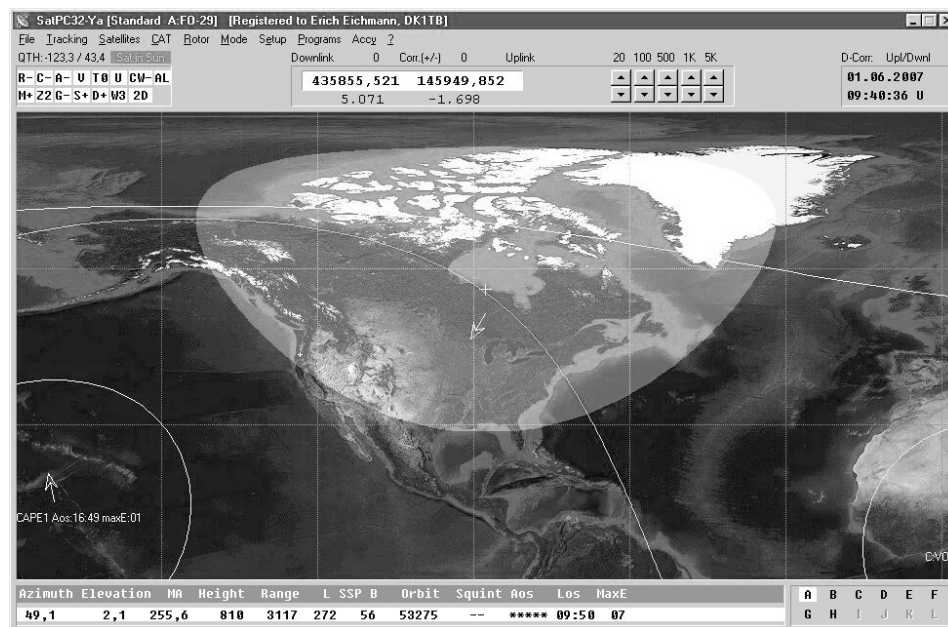
- Select 2D/3D map with a single mouse click
- Select Political/Physical map with a single mouse click
- AOS voice announcement
- Countdown program displays next AOS of your favorite satellites
- Automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: LVBTracker, Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/U3/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
Kenwood TS-790 and TS-2000
DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897, IC-706 and IC-7000.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, TS790A and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members).
Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.





LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- USB or serial interface
- Ethernet interface capable
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
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- Self-programmable, allows for easy software upgrades
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- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-589-6062 to order.

The complete units will be built in groups, so get your orders in early.

Units will be shipped as they become available.

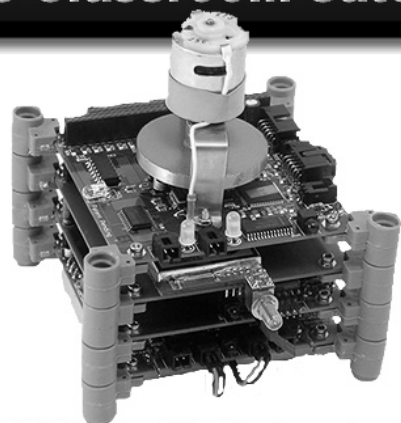
- 1) Bare board - \$20 + S&H - no parts kits available
- 2) Populated board, serial interface - \$100 + S&H - no kit with USB unit, rotor cable and LCD available, we do have a parts list with recommended part numbers and sources.
- 3) Custom Ten-Tec Enclosure powder coat, silk-screened, drilled/punched - \$50 + S&H
- 4) Complete unit - board, USB output, rotor cable, LCD, enclosure - \$200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: <http://www.LVBTracker.com>

Boards and complete units may be ordered from the AMSAT office at 301-589-6062 or from martha@amsat.org



The Classroom Satellite



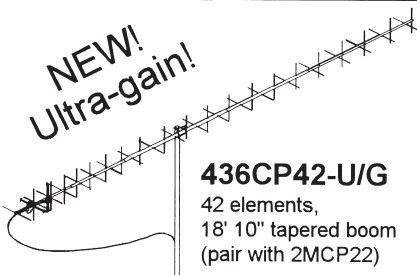
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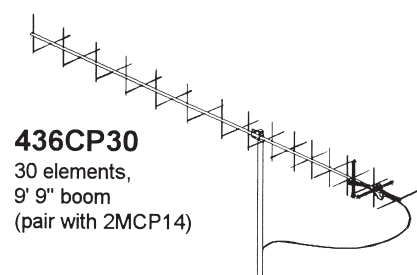
Find out more at <http://www.EyasSat.com> !

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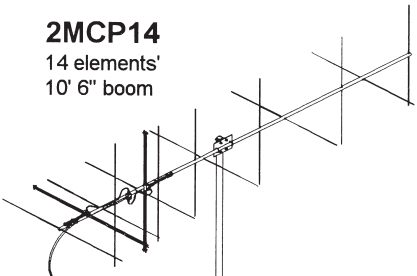
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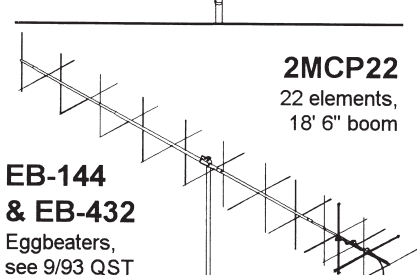
436CP42-U/G
42 elements,
18' 10" tapered boom
(pair with 2MCP22)



436CP30
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9' 9" boom
(pair with 2MCP14)

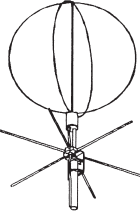


2MCP14
14 elements'
10' 6" boom



2MCP22
22 elements,
18' 6" boom

EB-144 & EB-432
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The Orbital Classroom, Column #14

AMSAT and Teacher Professional Development

© 2008 by Prof. H. Paul Shuch, N6TX

Former AMSAT Director of Education



The Orbital Classroom

Our last column discussed the National Science Education Standards. In it, I attempted to show why AMSAT must demonstrate compliance with those standards in developing a meaningful Teacher's Institute. It was my intention to show how AMSAT can provide a credible professional development opportunity for educators, while advancing our own educational goals. Since that column was submitted, there have been significant changes in AMSAT's educational direction. It is my hope to explain those changes in this, the final issue of The Orbital Classroom.

Most school districts tie advancement (and in some cases, continued employment) to specific continuing education requirements. Generally, a teacher is required to receive a specified number of Continuing Education Units (CEUs), during a stated period of time, to meet a given school district's professional development requirements.

Unfortunately, the scope of acceptable activities and level of rigor necessary to grant CEUs vary from state to state. But AMSAT intends to provide continuing education opportunities for teachers from all fifty states. To grant CEUs, we would need to have our curriculum scrutinized and approved by fifty Departments of Education in separate states (each of which may have different, possibly conflicting, standards). Thus, it is my recommendation that we NOT pursue granting of CEUs.

There is, however an alternative to CEUs. Most school districts will allow professional development credit for relevant postgraduate-level courses from any accredited university. And AMSAT, by virtue of its Memo of Understanding with the University of Maryland, Eastern Shore (UMES), is party to an educational partnership that just might make such postgraduate level courses feasible.

UMES is home to the Hawk Institute for Space Sciences (HISS), host for the AMSAT Satellite Integration Facility ('AMSAT Lab'). We have already partnered with HISS on a number of educational initiatives, including student involvement in satellite construction activities in our lab, and student participation in balloon launches carrying Amateur Radio payloads. So, using their facility to educate

educators is a logical next step.

Although UMES is an undergraduate institution, it is part of the University of Maryland system, which does indeed grant graduate credits. If our Teacher's Institutes can be approved by that university for graduate credit, participating educators from all states can apply it toward the continuing education and professional development requirements of their particular school districts.

OK, so we began to develop a game plan for offering accredited, post-graduate training for educators, through our existing university partner. Now, of what should such training consist? Clearly, we'd love to see schools across the country equipped with OSCAR groundstations, tracking and communicating through ham satellites. But remember, any effort in that direction must be consistent with the National Science Education Standards outlined in the previous Orbital Classroom column. Simply preparing teachers to have their students play ham radio through satellites isn't going to cut it.

Here's where a serious curriculum development effort appeared needed, and I am proud to say that several AMSAT educational volunteers stepped up to the plate. But, before reinventing the wheel, I thought it prudent to survey other professional development opportunities for educators, which also focused on satellite communication and related technologies. To my surprise, I found quite a few competing programs already well in place.

Closest to home for most AMSAT members is the excellent ARRL educational program headed by our friend Mark Spencer, WA8SME. Mark was most helpful and encouraging to me when first I was appointed AMSAT Director of Education in early 2006, and generously offered to share his curriculum with us. He presents four to six Teacher Institutes a year, in various parts of the country, and through a partnership with an accredited university, is able to offer participating teachers postgraduate credit suitable for their professional development needs. These weeklong intensive courses cover many aspects of Amateur Radio, including an excellent introduction to amateur satellites. In fact,

in their professional capacity as classroom teachers, a number of AMSAT members have already taken Mark's courses. As the national association for Amateur Radio in the US, ARRL has been quite successful in securing financial contributions toward its educational efforts. Consequently, many participating educators are able to attend these ARRL courses free of charge, and some have even been awarded equipment grants to equip their laboratory facilities and campus Amateur Radio stations. AMSAT salutes the ARRL for making this worthy educational contribution.

ARRL is not alone in its continuing education offerings, although the extent of its emphasis on Amateur Radio is unique. Such professional organizations as the American Astronomical Association, American Association for the Advancement of Science, American Institute of Aeronautics and Astronautics and others also offer professional development to educators, in areas that overlap AMSAT's expertise. Because of the extensive financial resources of these large organizations and their commercial sponsors, costs to individual teachers are minimal, with stipends offered to encourage the most cash-strapped school districts to participate. Often, these workshops are offered at exotic vacation venues, which makes it easier for participating educators to gain the support of their respective families. I once attended such a summer course myself, under the sponsorship of the school district where I was then employed. Although, regrettably, it lacked Amateur Radio content, that course emphasized the use of computers in the classroom at a time when that idea was still novel, and provided an enjoyable and professionally rewarding experience.

NASA has long promoted aerospace education through its SpaceMobile program, run for them for decades by the University of Oklahoma. The program featured laboratory and demonstration equipment built into vans, fanning out across the country to visit primary and secondary schools in every state. Astronauts are frequent speakers at SpaceMobile events, and though their emphasis has been motivation of students, many a classroom teacher has received professional development credit through SpaceMobile workshops.



10-10 International Club Station W6OI

Active on the Satellites

by Allen Mattis, N5AFV, n5afv@amsat.org

Recently, a new contract for the NASA Aerospace Education Services Project (AESP) was issued to the Pennsylvania State University's Center for Science and the Schools. With PSU becoming NASA's new ASEP higher education partner, some changes in emphasis ensued, which promised to prove valuable to AMSAT. Instead of just sending SpaceMobiles around to the K-12 schools to put on road shows for the students, they announced a new thrust in teacher continuing education. Because this meshes well with AMSAT's proposed professional development plans for educators, I met in December 2007 with Dr. Bill Carlsen, Penn State's Principal Investigator on this new NASA contract. And, from that meeting, an AMSAT action plan began to emerge.

As worthy as it might be for AMSAT to provide teachers with continuing education into satellite communications, I reasoned, the cost (both monetary and in terms of effort required) threatened to siphon off AMSAT resources already stretched thin by our various satellite development programs. Why not instead, I suggested, partner with ARRL, NASA, Penn State and AIAA, and everybody else already filling the educators' technology professional development niche? In January 2008, I proposed to the AMSAT leadership team that our talents could best be spent by developing, and volunteering to teach, satellite design, satellite construction and satellite operations *modules* for all of those organizations currently offering teacher continuing education in related fields. It's not as glamorous as having our own Teacher's Institute, I realize, but it just might be more compatible with AMSAT's primary mission.

I had thought I had made a reasonable case, but I am an educator, not a policy maker. Ultimately, the AMSAT Board decided to go in a different direction and in February 2008 I was asked to step down as AMSAT Director of Education. I will not second-guess our leadership in that decision, but did want the AMSAT membership to know the path that brought us to this juncture. And, I will continue to support, to whatever extent I am able, whatever educational efforts the AMSAT Board ultimately decides to pursue, consistent with our organization's vision and mission statements.

I urge all of you to support such future AMSAT educational efforts as well.



Satellite operators had the opportunity to work the 10-10 International club station, W6OI, on June 1, 2008 on passes of AO-27, SO-50 and AO-51. The occasion for this special event operation was to commemorate the 20th and what probably was the last 10-10 International Hill County Picnic.

10-10 International was founded in 1962 to encourage Amateur Radio use of the 10 meter band at a time when there was concern that the Federal Communications Commission might withdraw the band from the Amateur Radio frequencies as they had done several years before with the 11 meter band. Many newer members of AMSAT may not be aware that the 10 meter band was used by a number of early OSCAR satellites.

In the 1970's AO-6, AO-7 and AO-8 were all launched with Mode A Amateur Radio transponders that had downlinks in the 10 meter band. The Russian satellite RS-12/13 launched in 1991 had both Mode A and Mode K transponders with downlinks in

the 10 meter band. And in recent years AO-51, PCSat2 and NO-60 have all used the 10 meter band for a digital uplink frequency.

It should be no surprise that the 10-10 members who gathered for the Hill Country Picnic included a number of satellite operators. A total of 38 people attended the picnic. This total included 29 licensed Amateur Radio operators and 11 club stations were also represented by these amateurs. The attendees came from Texas, Mississippi, California, Florida, New York, Minnesota, New Hampshire, Arizona and Nebraska, as well as New Brunswick, Canada.

A total of four satellite passes were worked on the day of the picnic. Two passes of AO-51 were worked from EM00ng using an Icom W32A HT and an AL800 telescoping antenna. One pass each of AO-27 and SO-50 were also worked from a stationary mobile in grid square EL09ts. A total of 33 contacts were made with stations in 15 US states, 3 Mexican states and 3 Canadian provinces.



(Left to right) Keith Schlottman, KR7RK, Jack Moore, K5CC, Rob Ireland, VE9KM, Allen Mattis, N5AFV, Bill Heberling, WD5EDR, and Don Hinte, KA5EYH. Also present but not pictured was Bob Rodriguez, K5AUW.



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CanSat and AMSAT

by Jasper Veldman

Hello! I'm Jasper, I live in Holland and I'm sixteen years old. I'm currently working on the CanSat project with seven other people. We are building a satellite approximately the size of a cola can. In the test phase the CanSat design is going up into the atmosphere with a balloon to a height of about 150 meters. In the final test phase the CanSat is going into the air with an amateur rocket to a height of about 1000 meters.

Obviously there are a few requirements. The CanSat must weigh between the 365 and 375 grams, no dangerous items may be in the CanSat, it must be back on the ground in 90 seconds and everything must remain in the can at the end of the flight.

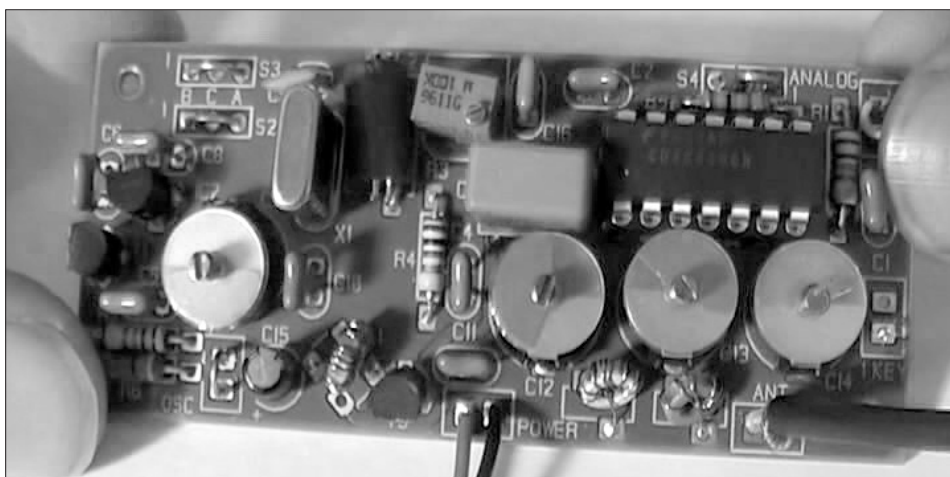
Most importantly, there are two missions. The first mission is the same for everyone and requires measuring the temperature and the air pressure during the flight. With those two measurements you can determine the altitude that has been reached.

The second mission is one that you must devise for yourself. After a brainstorming session we thought that our second mission would be a radio transmitter. We wanted to make a radio station of our CanSat. So we had to search for a powerful transmitter that could transmit for a distance of at least 1500 meters. At first we bought a transmitter which would have enough power output to

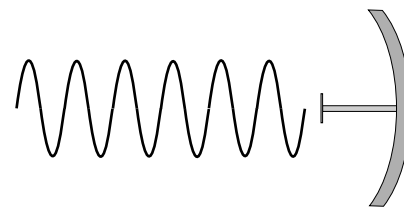
span a distance of around 1000 meters, but we broke it so we had to find a new one.

Then we came in contact with someone who thought we could build a 144 MHz transmitter, <http://www.qsl.net/on7yd/atx2.htm> from ON7YD. The transmitter was powerful enough with 200 mW of power and it was also small 78 x 33 x 15 mm (L x W x H). To be able to use the 144 MHz transmitter we needed a radio amateur to help us since that frequency falls within the Amateur Radio allocations.

Finally we found some help from two Dutch radio amateurs who were members of AMSAT and who wanted to help. The first ham, John, helped us to solder everything on the circuit board. He finished the transmitter in one day. Then the second amateur, Pim, tweaked the transmitter for us. First the transmitter was only sending beeps, but Pim tweaked it so that we could hook up an iPod Shuffle and could transmit audio. He also took care of the antenna and the battery cable. Then Pim took care of the modulation, he did such a good job that the output was at maximum. Here you can see a short movie of the transmitter and how it is constructed: <http://www.youtube.com/watch?v=pfe1FRPQV74>. On 16 May we have the first round, we are hoping that we will win. Wish us luck! 🍀



CAN-SAT Transmitter



Telescope Image of AO-40

by Patrick Seitzer, Ph.D, WA4DSR,
pseitzer@umich.edu

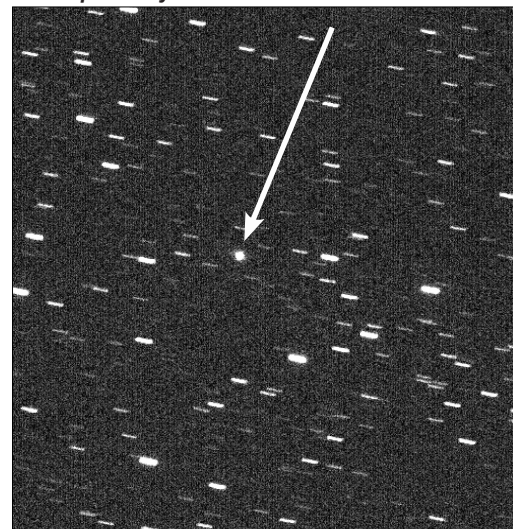
Below is an image of the Amateur Radio satellite AO-40 taken with the University of Michigan's Curtis-Schmidt telescope at Cerro Tololo Inter-American Observatory in Chile. This is a 5 second exposure through a V filter. The streaks are stars, as the telescope was tracking the spacecraft.

During a 15 minute tracking sequence, the brightness changed smoothly by about 60%. No large brightness variations were seen as might be expected if the spacecraft was rapidly tumbling. Does anyone know if AO-40 had/has any sort of stabilization?

This telescope is dedicated to a NASA project for optical studies of orbital debris called MODEST (for Michigan Orbital DEbris Survey Telescope). Unfortunately, AO-40 falls into the category of space debris having suffered a major failure in January 2004.

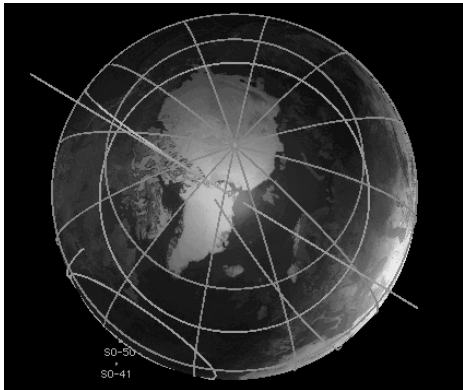
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AO-40 photo by WA4DSR.



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Giant Leaps for the UF CubeSat Team

by Svetlana Shkolyar, galaxz3002@ufl.edu and Dante Buckley, KI4LDJ, dante35@ufl.edu

The University of Florida Small Satellite Design Club (SSDC) has been busy this Spring 2008 semester. Members have been making astronomical leaps toward furthering the goals of not only the UF SSDC but also of the Gator Amateur Radio Club (GARC) and the Space Systems Group (SSG). They have been involved in everything from steering their way to a tied-for-first-place finish at a satellite

plans. They wished the UF CubeSat team the best and looked forward to learning more about their accomplishments at next year's fair.

On April 18 three UF organizations, the SSG, SSDC and GARC jointly declared the day CubeSat Appreciation Day on campus. The agenda included portable satellite communication demonstrations, lab tours with CubeSat Hardware demonstration

and even a visit to the Gator Amateur Radio Club station, W4DFU.

On May 9 four universities participated in the fourth Annual FUNSAT (Florida University Satellite Design Competition) sponsored by the Florida Space Grant Consortium, Space

magnetorquer attitude control system.

Florida International University (FIU) placed second with their payload design utilizing Iridium's 9601 transceiver in a CubeSat. Iridium is a constellation of communication satellites in a 780 km altitude whose transceivers operate in the L band.

The missions of the Florida Institute of Technology and their satellite, FITSAT IV, and of UF's ASTREC-I CubeSat mission, tied for first place.

FITSAT-IV's mission determines if Shewanella MR-1 bacteria could survive in space. Shewanella oneidensis MR-1 is being developed as the payload because of its potential use for generating an electric current, for waste management and for water purification during long-duration space missions.

UF's ASTREC-I CubeSat mission proposed an on-orbit demonstration of a compact three-axis attitude controller capable of rapid retargeting and precision pointing.

The ASTREC-I mission and FIT's (Florida



The CubeSat Appreciation Day Team.

design competition involving a conceptual design report, (detailed design report and presentation concluding in May) to using their engineering expertise at Engineering Fairs this February. They even had time to declare a local holiday in the process.

On February 18 and 19 during Engineer's Week, the SSDC and GARC received two awards at the Engineering and Science Fair. Over 2,000 students of all ages attended the Engineering Fair from impressionable kindergarteners to eager high school students already making decisions about their college

Florida, and Florida Space Institute.

Embry Riddle Aeronautical University's S.M.A.C.S. (Sun-Pointing Magnetically Actuated Cube Satellite) came in third place. Their mission concept was to implement a three-axis



The SSDC & GARC E Fair Team.



FUNSAT IV winners.

Institute of Technology) FITSAT IV were both awarded \$7500 for the development of a flight model CubeSat. The FUNSAT IV sponsors (FSGC, Space FL and FSI) have promised to seek funding for launch cost if possible. FIU received \$1000 for second place; ERAU received \$500 for third place.

Please visit the UF Small Satellite Design Club Web page, www.ufsmallsat.com or contact the SSG Mission Office at 352-846-1667 for more information. ☺



Using Fiber Optics to Avoid Ground Loops

John M. Franke, WA4WDL, jmfranke@cox.net

Before I get started, let me make one thing clear: I hate ground loops! I have been working on a GPS driven clock for my apartment. The clock uses a two-stage TTL counter to count seconds from a GPS receiver supplying a 1 pps (one pulse per second) signal. The seconds counter increments a mechanical slave clock every 60 seconds. The Rockwell Jupiter GPS receiver I use is from the early 2000s. The seconds display consists of two Burroughs Nixie® tubes from the mid 1950s. The mechanical clock movement is a slave clock movement from a clock used in schools back in the late 1920s. The result is an interesting mix of technologies covering eighty years.

shown in Figure 1. Although not shown, each integrated circuit is bypassed at its socket with a 0.1mF capacitor. Originally, the seconds counter directly received the buffered 1 pps signal from my GPS receiver. This worked fine for a month or so. Then, I relocated the clock breadboard, see Photo A, about ten feet from the GPS receiver and powered the receiver and the clock from separate ac outlets. Several times a day I checked the clock against CHU on 7.335 MHz, a General Radio 1123A synchrometer, which is driven from a military surplus URQ-10 crystal oscillator and passes of Russian low-orbit navigation satellites on 149.940, 149.970, or 150.030

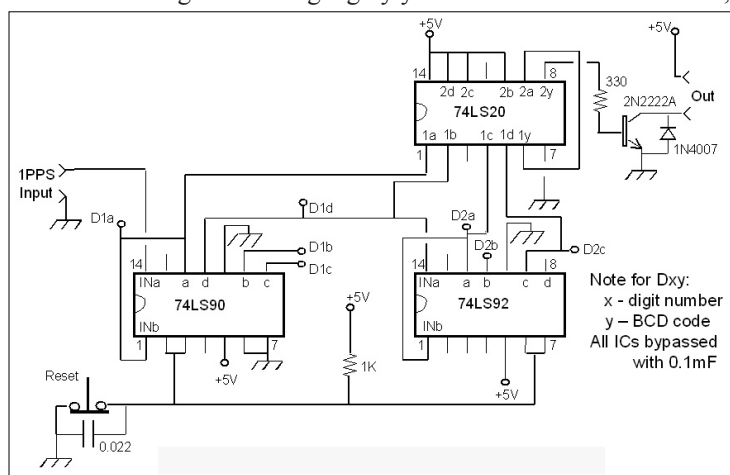


Figure 1: Seconds counter for GPS Impulse Clock.

The seconds counter uses a 74LS90 to count the unit seconds and a 74LS92 to count the tens of seconds. A 74LS20 AND gate is used to decode second "59" and energize the solenoid which increments the clock movement when it is released as the counter

clock is a different matter. An extra pulse every day or two is intolerable.

The first cure I tried was going back to powering everything from the same ac outlet. This eliminated the false counts, but running the extra cables was a nuisance. There had

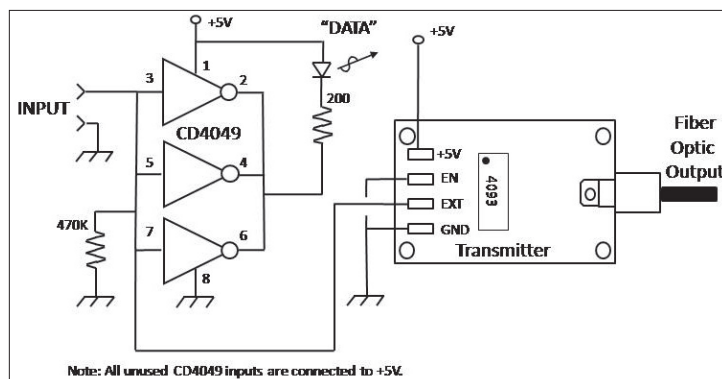


Figure 2: Schematic of fiber optic interface.

is reset to "00." 74LSXX series integrated circuits were used to reduce the power drain over regular 74XX series integrated circuits. The schematic for the seconds counter is

the seconds counter. But, I was still seeing an extra count every couple days or so. So, I added an opto coupler to the 1 pps cable to break the ground loop. I used a Hewlett-

Packard 2631 optocoupler because I had one on hand. The 1 pps coax cable was grounded only at the GPS receiver. This worked for several weeks before there were any more extra counts. But then, extra counts began appearing. The best I could figure was that RF from a new neighbor's cell phone was being picked up by the sheath of the 1 pps signal coax cable. What I needed was a non-conducting cable for the 1 pps signal.

Such a cable does exist. It is called optical fiber. The term fiber optics covers a broad field encompassing plastic fibers, glass fibers, single mode fibers and multimode fibers. I decided to start with the simplest of systems, a multimode plastic optical fiber. The light source can be semiconductor diode lasers or visible or near infrared LEDs. I chose to use visible LEDs, which are less efficient, but I can visually ascertain whether or not a signal is present. There is a myriad of connector choices. Again, I went with the simplest, a friction grip bare end coupling.

Industrial Fiber Optics, at <http://i-fiberoptics.com/index.php>, produces a line of educational and hobbyist fiber optic components and kits. Datasheets for individual detectors and emitters are available on their web site. Their products are distributed through many outlets including: Circuit Specialists, Inc. at <http://www.web-tronics.com/>, Digi-Key at <http://www.digikey.com/>, and Ocean State Electronics at http://www.oselectronics.com/ose_p24.htm.

For my first experiments, I chose to use the Industrial Fiber Optics Digital Kit IF-E22. The kit and separate emitters and detectors are shown in Photo B. The instruction manual, which covers the construction and use of the kit along with a brief introduction to fiber optics, is available online at <http://i-fiberoptics.com/pdf/IF-E22Bklt2000.pdf>. The kit uses a visible, red LED source and the input and outputs are TTL and CMOS compatible. The transmitter circuit board has an onboard oscillator that is handy for

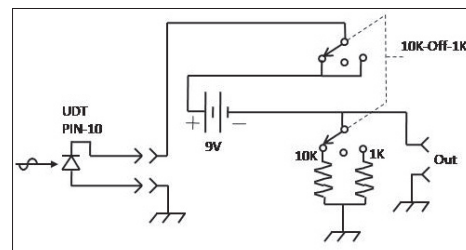


Figure 3: Fiber optic power meter schematic.

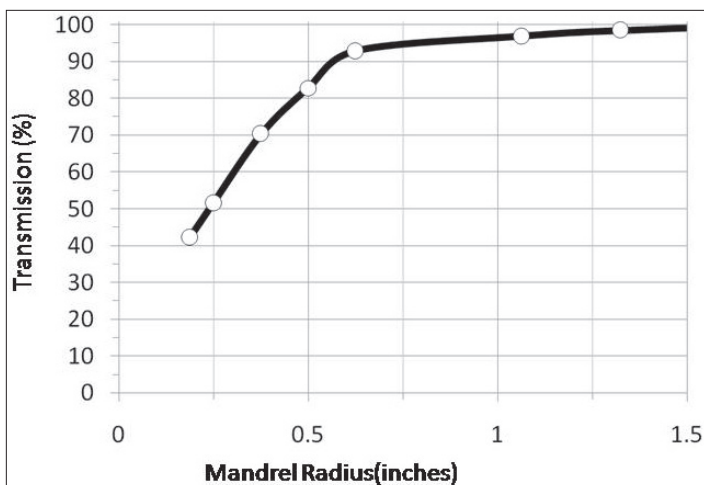


Figure 4: Fiber loss versus bend radius.

testing the link. The kit comes with a one-meter fiber optic cable, but I experienced no problems using a 100-foot fiber optic cable. I will eventually reduce the length of the fiber optic cable to twenty feet. For now it is comforting to know the system works well with the longer cable. Later, I did measure

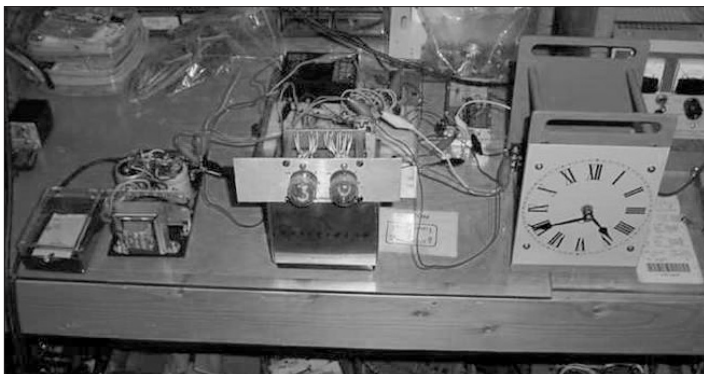


Photo A: Breadboard of GPS impulse clock showing power supply, seconds counter and mechanical clock.

the transmission of a 100-foot cable versus a 3-foot cable. The transmission of the 100-foot cable was 31% for a loss of 5.1 dB more than the 3-foot cable. The receiver has two data outputs, normal and inverted. Since the TTL chips in the seconds counter

to house the fiber optic data transmitter. The schematic of the transmitter link is depicted in Figure 2. A 7805 three terminal regulator was used to convert the NIM-bin supplied 12V to 5V. The transmitter module was mounted inside the NIM-bin module on standoffs. A CD4049 was added to drive a LED panel indicator to indicate when a drive signal was present.

As shown in Photo C, a short fiber optic cable was used to bring the optical signal to a fiber optic bulkhead feedthrough mounted on the faceplate. The bulkhead feedthrough, model IF-C-S4, is just an open straight through tube with two cable squeeze clamps. Coupling from one cable to the next is done by close coupling produced when the two fiber ends are butted up against each other inside the coupling. I did not measure the loss for the feedthrough because it depends on the alignment every time the cable is inserted. A 2" diameter loop was formed to reduce fiber optic losses. The instruction manual makes no reference to a critical bend radius.

Reducing the bend radius causes two problems. First, the differential stress changes the difference in the index

of refraction between the core and the cladding. Second, the bend changes the angle of incidence of the light rays in the core as they strike the cladding. The result is light leaks out of the core and transmission losses increase. When I worked at NASA, we came upon an interesting problem. We had installed an array of glass optical fibers in the wing of an aircraft model. Light coming from the cut and polished ends of the fibers was viewed by multiple cameras in the wind tunnel to stereo-optically measure the orientation and deflection of the wing under loads. Everything worked fine until the wind tunnel was cooled to liquid nitrogen temperatures (-309°F) to change the Reynolds number of the gas. Once cooled there was no longer any light visible through the fiber. The stress

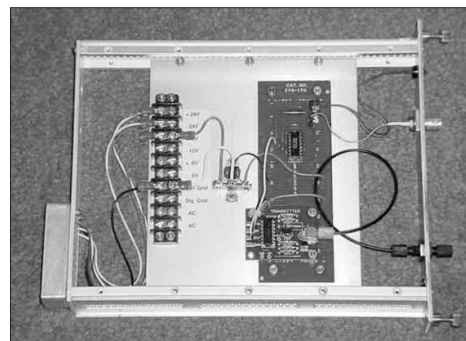


Photo C: View of fiber optic interface inside NIM-bin module.

from the differential thermal contraction of the cladding and core changed their relative indices of refraction and the light leaked from the fiber cable along its length. Using plastic fiber, we had lots of transmitted light. So, in that case, using less expensive, higher

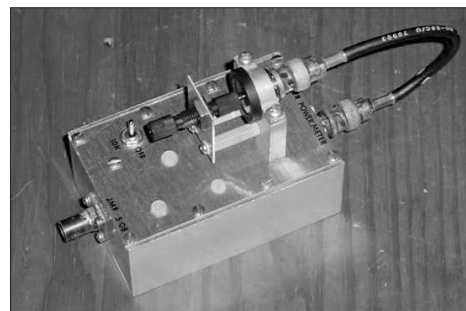


Photo D: Fiber optic power meter.

loss, plastic optical fiber was the solution. I did measure the fiber loss as a function of bend radius for a 360° wrap around cylindrical mandrels of different diameters. I used the transmitter's onboard square wave oscillator as the signal source, but I had to fabricate my own optical receiver to avoid any detector non-linearity.

To make a linear optical power detector,

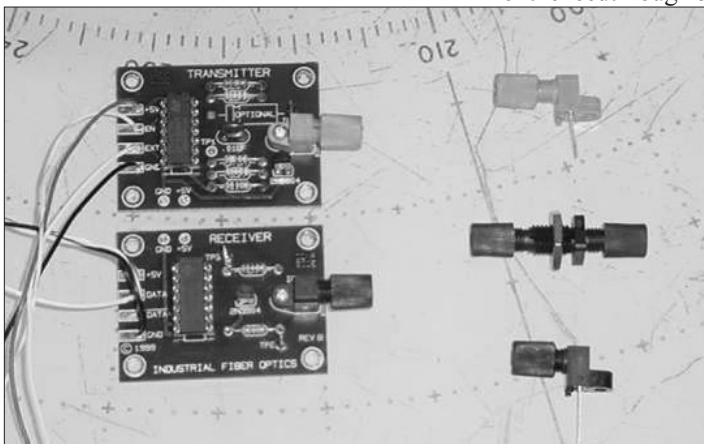


Photo B (CW from upper left): Fiber optic transmitter, detector, bulkhead feedthrough, emitter and fiber optic receiver.

I used a reversed biased PIN photodiode. See Figure 3. The photodiode is being operated in the photoconductive mode versus photovoltaic. The photodiode, a UDT PIN-10, is reversed biased with a 9V battery. The higher the reverse bias, the lower the junction capacitance and the higher the detector frequency response. Of course, the bias must be well below the reverse breakdown voltage of the photodiode. The load resistor is switchable between a 1K and a 10K resistor. When reversed biased, the photodiode current is a linear function of optical power. The arrangement is linear over more than eight decades. The typical sensitivity for red light is around 0.5mA/mW. Absolute calibration is not important. The physical arrangement is shown in Photo D. The output voltage is increasingly negative as the optical power increases. Figure 4 shows the per cent transmission for a single wrap around various cylindrical mandrels having radii from 3" down to 3/16".

I wired together an IFD95T detector and interfaced it with the seconds counter to replace the receiver board that came with the IF-E22 trainer kit. The detector only costs \$4.95 and has an internal Schmidt trigger level converter. Whereas the two-lead detectors and two-lead emitter leads are on 0.1" centers, the three-lead detector leads are on 0.075" centers. But, carefully spreading the leads will permit the three-lead detectors to be mounted on common 0.1" spacing prototyping circuit boards. I did have to add an inverter following the detector because the detector output follows the input light level and the TTL counter chips increment on a falling edge. Negative logic versions of the detector are available as special options.

With an optic fiber, there have been no extra counts after over two months (>5 million seconds) of continuous operation. ☺

Figure 1

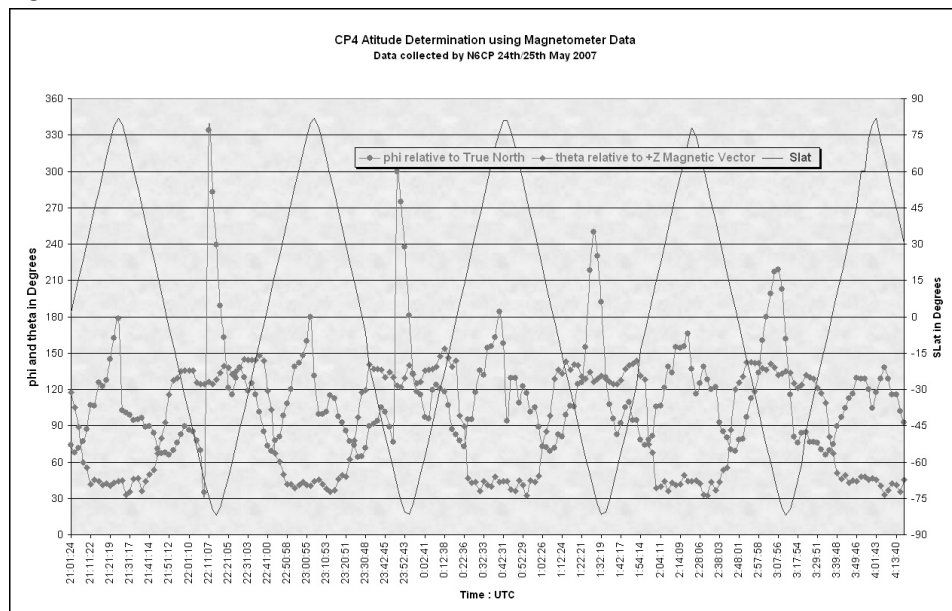


Figure 2

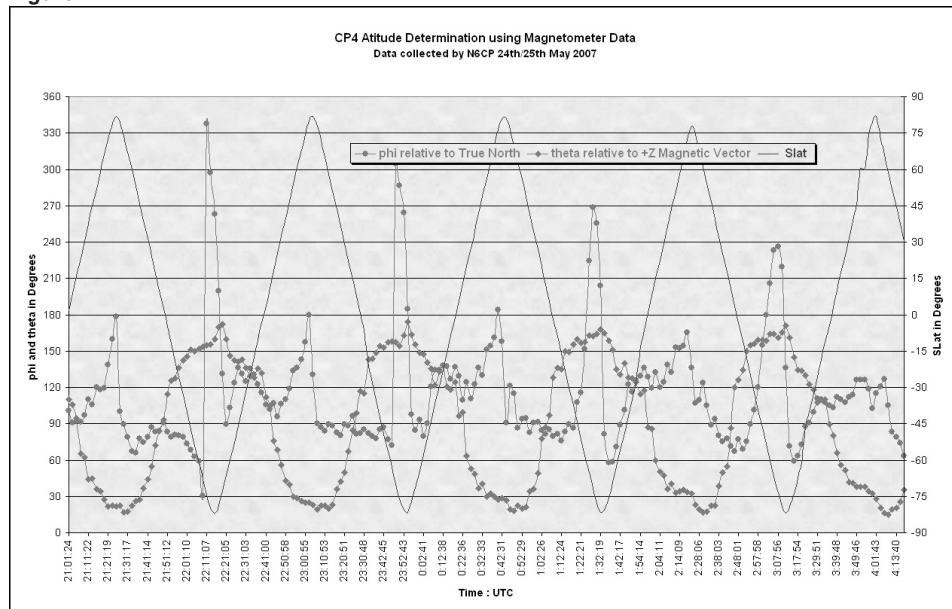


Figure 3

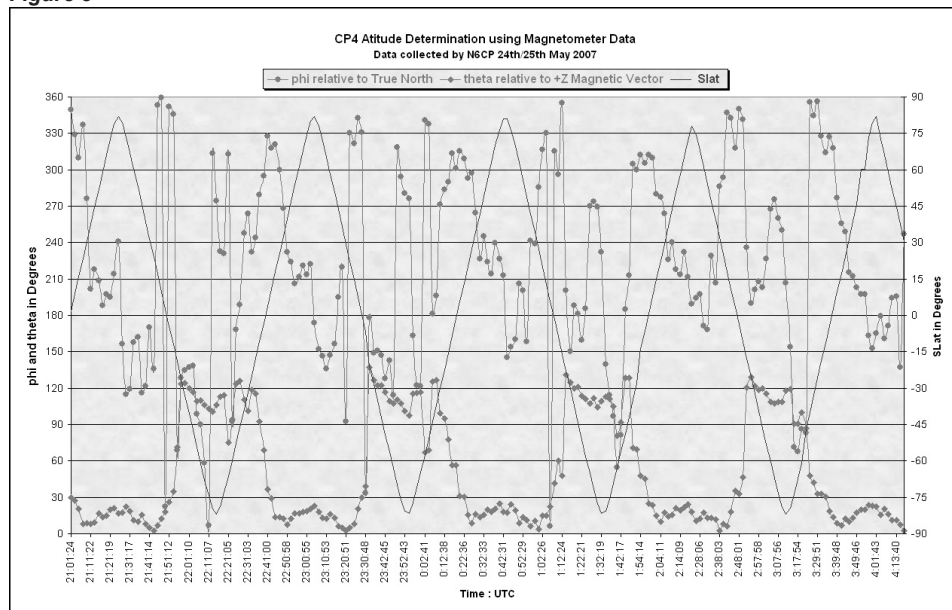


Figure 4

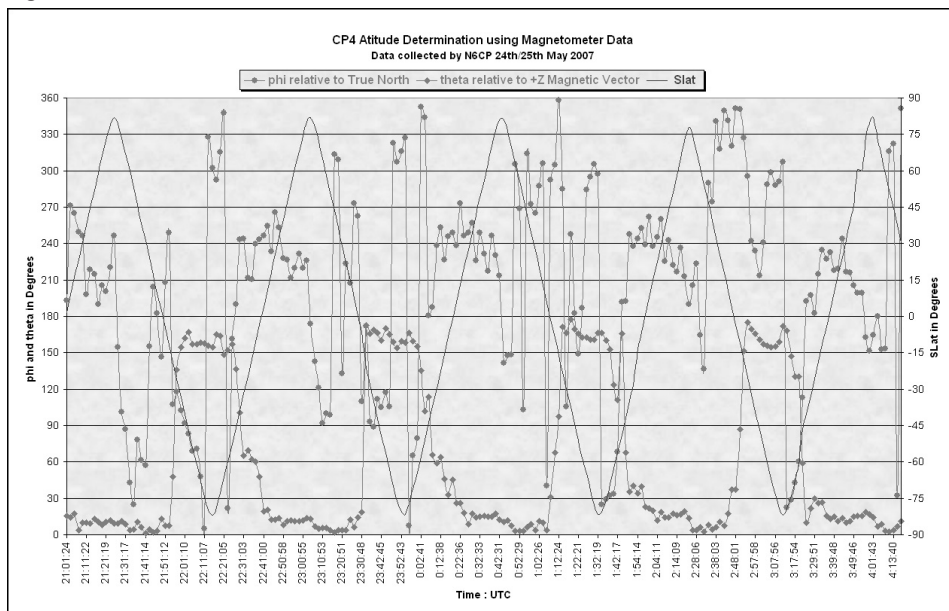


Figure 5

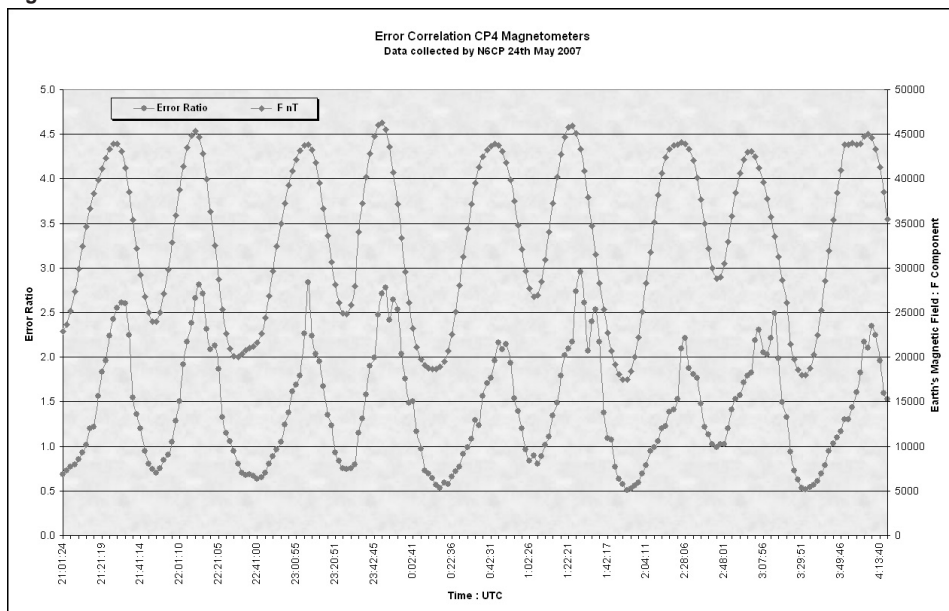


Figure 6A

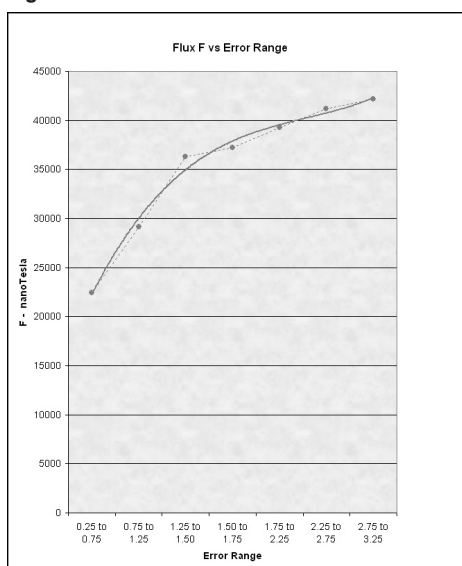
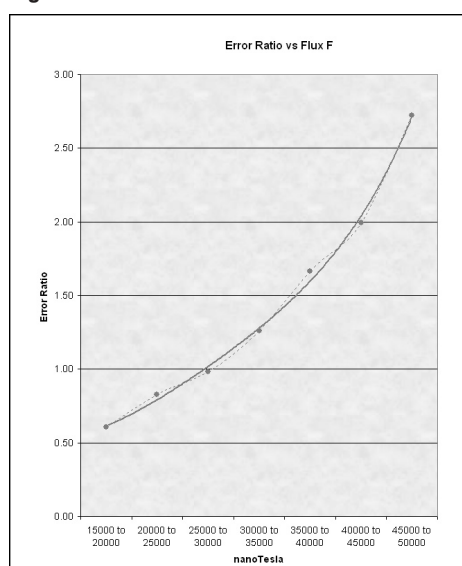


Figure 6B



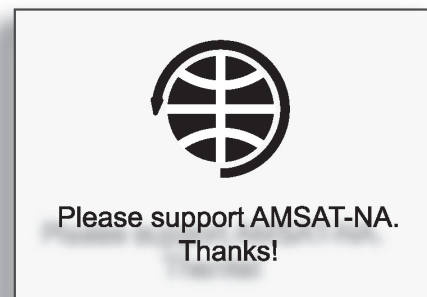
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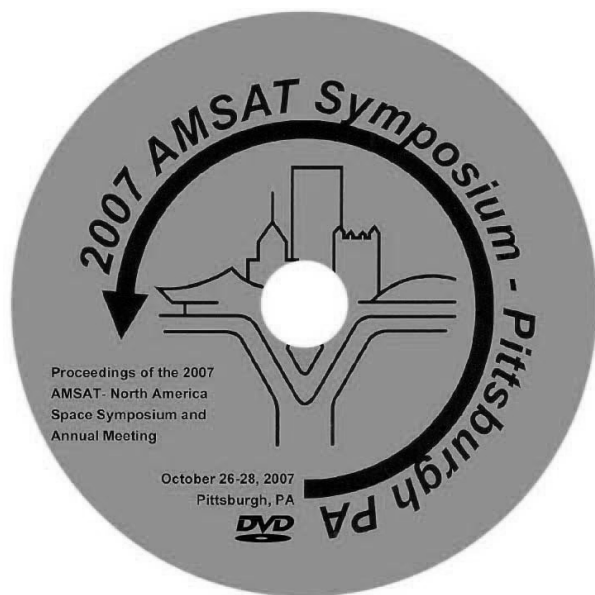
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Learn DSP By Programming Your PC; Part 5: Turn Your PC into a Radio Receiver

by Richard F. Crow, N2SPI, n2spi@amsat.org

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Introduction

How would you like to turn your PC into a radio receiver? That's right, turn it into an SDR (Software Defined Radio). Furthermore, how would you like to program your PC

product detector is shown in Figure 1.

So, the challenge here is to create a 11.025 kHz local oscillator and frequency mixer combination in software, and then use it to

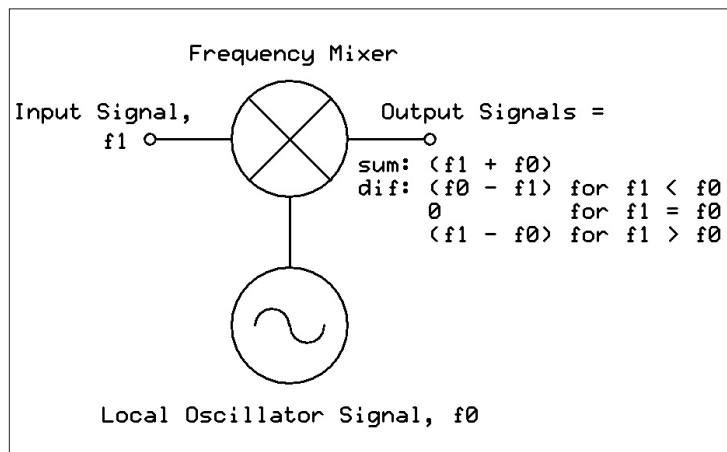


Figure 1: A product detector.

to do this yourself instead of installing a black-box software package developed by someone else? Interested? Well, that's what's going to happen in this article. This article will present the core software for an SDR that receives SSB (single Sideband) and CW (continuous wave) signals. Specifically, this article will explain how to program a PC to implement a 11.025 kHz product detector. In addition, to provide real radio signals from the 40-meter amateur band, the instructions for building a simple 7000 kHz to 11 kHz receive converter are included. When done, RF (radio frequency) signals downconverted from 40 meters will come into the sound card and SSB/CW audio will come out. Again, the material here builds on previous parts of this series that started with Part 1 in the July/August 2007 issue of *The AMSAT Journal*. If you have difficulty typing-up the software here yourself, I am developing a Web site where you can download it. Its URL will be announced in the next *AMSAT Journal*.

The Software Product Detector

What is a product detector? A product detector is a frequency mixer and local oscillator combination that shifts the high frequencies of RF signals you can't hear down to audio frequencies that you can hear. If this isn't clear, look up frequency mixer, local oscillator and product detector at <http://en.wikipedia.org>. A block diagram of a

product detector is shown in Figure 1. So, the challenge here is to create a 11.025 kHz local oscillator and frequency mixer combination in software, and then use it to process consecutive samples of the input signal. Figure 2 shows the C source code for this. Edit function DigitalSignalProcessing() in passthru.c from Part 4 to match Figure 2, compile, and run it.

First, let's look at the local oscillator section. This is simply a software sine wave generator like the one already presented in Part 2.

However, the software here is simpler because it's for a fixed frequency. To test and hear this oscillator by itself, replace 11025 on line 323 of Figure 2 with say 440. Then, replace line 377 with:

```
pOut[i] = (SHORT)LocalOscSignal;
```

As for the mixer section, the thing to know is that frequency mixing results from the multiplication of two signals in the time domain. That's right, ordinary multiplication. Maybe that's why it's called a "product" detector. Now, a local oscillator and frequency mixer by itself will, in fact, demodulate SSB/CW signals. To experience this, restore line 323 and replace line 377 with:

```
pOut[i] = (SHORT) (Mout/16384);
```

However, a local oscillator and frequency mixer by itself will spew out annoying high frequency audio from adjacent signals. To fix this, a 3 kHz low pass filter follows the frequency mixer as shown in Figure 2. This is the same 3 kHz low pass filter as in Part 3 except it's been re-coded to make it more compact. To test this filter software by itself, restore line 377 and replace line 360 with:

```
Fin = (LONG)pIn[i];
```

Then, use an audio generator, such as a second PC with sine wave software from Part 2, to test the filter as described in Part 3. In addition, test the unmodified product detector

software with the generator. Compare these results to what's listed in Figure 1. Lastly, if Figure 2 looks like "Greek" to you, learn the C programming language now, as outlined in Part 1, to move forward from here.

The Receive Converter

The maximum sample rate of a typical PC sound card is 48 kHz. So, the highest frequency it can handle is 24 kHz as determined by the Nyquist limit. The sample rate used here, in fact, is 44.1 kHz making the highest frequency 22.05 kHz. As a result, signals with higher frequencies need to be downconverted to what the sound card can handle. According to classic radio technology, the way to do this is use some more mixers and local oscillators. Just as in the product detector software above, that's what's in the receive converter here. Except now the mixers and oscillators are implemented in analog hardware that can handle higher frequencies.

Now, I believe the construction of a receive converter should be within the grasp of as many readers as possible. So, I've chosen the simplest design imaginable. Admittedly, this results in some performance issues. But this circuit of only 10 capacitors, 2 inductors and 1 integrated circuit can actually pull in clear signals most of the time. And later it can be improved upon to address performance concerns. Figure 3 shows a photo of the receive converter. Figure 4 shows the schematic and Figure 5 shows the parts list.

Building the Receive Converter

The receive converter will be built on a solderless breadboard. See Figure 6. Note that the breadboard is arranged in rows: 1, 2, 3, ...64, and columns: A, B, C, ... J. There are also + and - columns on the outside edges. The numbered rows are electrically isolated. However, within each row, columns A, B, C, D, and E are internally connected, and separately, columns F, G, H, I and J are connected. As desired, a jumper made from #22 AWG solid hook-up wire or an electronic component is used to connect one row to another. A set of such jumpers comes with the breadboard in the parts list. By comparison, all the rows of a + column are connected together. Separately, the rows of the adjacent - column are connected. The + column is intended as a +V bus and the -



```

//===== Line 318 =====
void DigitalSignalProcessing( PSHORT pIn, PSHORT pOut )
{
    // Creates a 11.025 kHz Product Detector followed by a 3kHz LPF

#define OSC_FREQ          11025 //323)define Local Osc freq
#define TWO_PI            6.28318
#define WT_INCREMENT      ((TWO_PI * OSC_FREQ)/SAMPLE_RATE)
#define NUM_FILTER_TAPS   31
#define TAPS_MINUS_1      (NUM_FILTER_TAPS - 1)

    int i; //329)=var for indexing pIn/pOut
    static float wt; //330)=rotat'g angle,Angular Freq
    LONG LocalOscSignal; //331)=signl from LocalOscillator
    LONG Mout; //332)=Frequency-Mixer output
    LONG Fin; //333)=Filter input
    LONG Fout; //334)=Filter output
    int j; //335)=loop'g index for array h[]
    static int x = 0; //336)=(circular) index for Acc[]
    static LONG Acc[ TAPS_MINUS_1 ]; //337)=Acc[],now a circular buffr
    SHORT h[ NUM_FILTER_TAPS ]={ //338)=3KHz LPF,WinSinc,Blackman4
    0x0000, 0x0000, 0xFFFE, 0xFFF7, 0xFFE5, 0xFFC8, 0xFFAE, 0xFFBE,
    0x003F, 0x0184, 0x03CB, 0x0711, 0x0AF3, 0x0EB4, 0x1172, 0x1273,
    0x1172, 0x0EB4, 0x0AF3, 0x0711, 0x03CB, 0x0184, 0x003F, 0xFFBE,
    0xFFAE, 0xFFC8, 0xFFE5, 0xFFF7, 0xFFFE, 0x0000, 0x0000 };
    //===== Line 343 =====
    for(i=0 ; i<BUFFER_SIZE ; i++) //344)LoopThruAll pIn/pOut sampls
    {
        //----- Local Oscillator Section -----

        LocalOscSignal = (LONG)( 32767.0 * sin( (double)wt ) );

        wt = wt + WT_INCREMENT; //350)add radians/sampl increment
        if( wt > TWO_PI ) //351)if wt exceeds TWO_PI...
            wt = wt - TWO_PI; //352)...subtract TWO_PI from it

        //----- Frequency Mixer Section -----

        Mout = (LONG)pIn[i] * LocalOscSignal; //"mix it up"

        //----- Lowpass Filter Section -----

        Fin = Mout / 16384; //360)normalize & input to filter
        Fout = Acc[x] + Fin * (LONG)h[0]; //calc resp @h[0] & harvest
        Acc[x] = 0; //362)clr old data,re-init Acc[x]

        x++; //364)point @ next Acc[] location
        if(x >= TAPS_MINUS_1) //365)if beyond end of Acc[],...
            x = 0; //366)..re-circulate to beginning

        for(j=1 ; j<NUM_FILTER_TAPS ; j++) //loop 2 calc rest of resp's
        {
            Acc[x] = Acc[x] + Fin * (LONG)h[j];

            x++; //372)point @ next Acc[] location
            if(x >= TAPS_MINUS_1) //373)if beyond end of Acc[],...
                x = 0; //374)..re-circulate to beginning
        }
        //-----
        pOut[i] = (SHORT)(Fout/16384); //377)normalize and output
    }
    //379)(end of "DigitalSig...()" )
}
//===== Line 380 =====

```

Figure 2: The C source code listing for a 11.025 kHz Product Detector followed by a 3 kHz low pass filter.

column is for a -V, or ground, bus.

In addition to the breadboard, you'll need small needle nose pliers (smooth jaws preferred), a wire cutter, a wire stripper for #22 wire and a small 1/8 inch flat blade screwdriver. You'll also need an X-acto knife, extra #11 blades and a small block of wood for a cutting board. As for test equipment, the minimum is a shortwave radio receiver that can tune the 40-meter amateur band, 7.0 to 7.3 MHz. Also, an electrical multimeter (volt-ohm-milliammeter) may be required. And finally, a shortwave antenna connected to a 50 or 75 ohm coaxial cable transmission line is needed as an input to the converter. A 40-meter dipole antenna is ideal. Before starting, stick the rubber feet mentioned in the parts list at the four corners of the breadboard.

Building Stage 1

To start, just wire-up B1, C3 and U1 for the DC power circuit and C4, C5, C6 and L2 for the local oscillator circuit, as shown in Figure 6. Plugging the jumper wires and components into the breadboard is pretty straight forward, except for L2. This is a 10.7 MHz IF transformer that needs to be modified before it can be inserted.

First, if using a 10.7 MHz IF transformer with an internal capacitor, remove the capacitor by crushing it with the blade of the 1/8 inch screwdriver. Note that the 10.7 MHz transformer listed in the parts list, Mouser # 42IF124-RC, does not have this capacitor. Next, remove the IF transformer's metal enclosure. To do this, grab a tab at the bottom of the enclosure with the needle nose pliers, wiggle the pliers, and lift the wall of the enclosure outward away from the insides of the transformer. Do this for both tabs until the insides slide out of the enclosure when pushed from above with the 1/8-inch screwdriver. Then, look at the bottom of IF transformer. Note there is one row with 3 pins in it. This is the reference row. Use the wire cutters to clip the center pin in the reference row being careful not to disturb any of the microscopic coil wires soldered to it. At this point, the IF transformer's four remaining pins should plug into the breadboard. However, they may have to be bent outward a bit with the needle nose pliers. A few IF transformers may

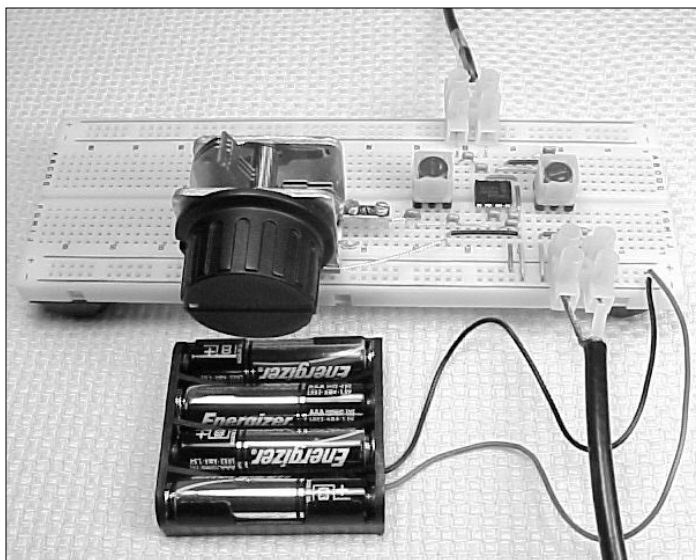


Figure 3: The 7000 kHz to 11 kHz Receive Converter.

get destroyed at first, so order extras. The two corner pins of the reference row are connected to the secondary winding of the IF transformer. The two other pins in the row across from it are connected to the primary winding. L2 uses the secondary winding.

Once everything is connected as shown in Figure 6, install fresh batteries in the battery holder B1 and see if the local oscillator is working. Set the shortwave receiver to 7 MHz, in SSB/CW mode if possible, with its antenna within a few inches of L2. Now, gently turn L2's slotted core clockwise until it's down as far as it will go. Then turn the core counter-clockwise up 1 turn. Gently rock the core back and forth around this position until the local oscillator's signal is heard. A non-metallic alignment tool, such as from DigiKey# K513-ND, is best for this. If the local oscillator is working, power-down the breadboard and proceed to stage 2.

C7 and C8 as shown in Figure 7. Here, the air variable tuning capacitor C8 needs to be prepped. 1) Make a solderless connector by, first, choosing one of the two terminals in a Eurostyle terminal strip, DigiKey# WM15900-ND. Next, screw both screws all the way in and use the wire cutters to clip off both plastic screw towers. Now, unscrew both screws until they fall out and push the terminal's metal barrel out of the plastic housing. Then, re-install the screws in the barrel but keep them out of the wire chamber for now. 2) As shown in Figure 7, use the wire cutters to trim the capacitor's back solder lug just enough until the solderless connector slides over it. Look at the capacitor's front solder lug in Figure 7 to see how much to trim. Tighten the appropriate screw to secure the solderless connector to the capacitor's lug making sure it's not shorted against the capacitor's body. 3) Select one of the longer #22 AWG

If not, re-check the wiring and component values. The 0.1 uF capacitors are marked "104" in tiny numbers, the 150 pF capacitors are marked "151", and the 560 pF capacitors are "561". Use an ohmmeter to check for electrical continuity between the reference row corner pins of L2. And, use a voltmeter to verify that there is +6 volts at U1 pin 8 with respect to U1 pin 3.

Building Stage 2

For stage 2 connect

jumper wires from the kit that comes with the breadboard and strip all the insulation from it. Then, insert one end into the solderless connector attached to the capacitor and tighten the appropriate screw. 4) Select another one of the longer #22 AWG jumper wires that comes with the breadboard and strip all the insulation from it. Install the 4-40 x 1/4 inch machine screw in the threaded hole below the capacitor's shaft and wrap the end of the wire clockwise around it in hook-like fashion. Use the needle nose pliers to crimp the wire snugly around the screw. Then, tighten the screw to secure this wire to the capacitor's body. 5) Dry mount the variable capacitor on the breadboard, form its wires, and trim them so they insert into the breadboard as shown in Figure 7. 6) Remove the variable capacitor from the breadboard and de-grease the bottom of it with a paper towel moistened with a spray cleaner, like Windex. Wipe dry. Cut a piece of (double-sided, foam-core) mounting tape that is 3/4 inches wide by 1 inch long and apply it to the bottom of the capacitor. Then, guide the capacitor's wires into the appropriate holes and mount it on the breadboard. Find the "Scotch Heavy Duty Mounting Tape 114, 1 in x 50 in Roll", or equivalent, at craft stores like A.C Moore or Michaels. Though not shown in Figure 7, attach the tuning knob, Mouser# 450-2039-GRX, to the shaft of the variable capacitor.

Power-up the breadboard again and set the shortwave receiver to $(7150 - 11) = 7139$ kHz. Tune C8 for maximum capacitance (plates fully meshed). Now, adjust L2 until the local oscillator's signal is heard. Then, set the shortwave receiver to $(7300 - 11) = 7289$ kHz. Now, listen for the local oscillator's signal while tuning C8 from maximum to minimum capacitance. If nothing heard, set the receiver 10 kHz lower to 7279 kHz and try again. This configures the converter to receive the 40-meter SSB voice band from 7150 to 7300 kHz. If the 40-meter CW band is desired, re-adjust L2 in a similar manner to receive 7000 to 7150 kHz. If the local oscillator is working as described above, power-down and proceed to stage 3.

Building Stage 3

Install the remaining parts on the breadboard as shown in Figure 8. In particular, install C1, L1 and C2 to provide the antenna input circuit. Note that L1 needs to be prepared the same as L2 and L1's reference row corner pins connect to C2. The center conductor of the coaxial cable from the antenna connects

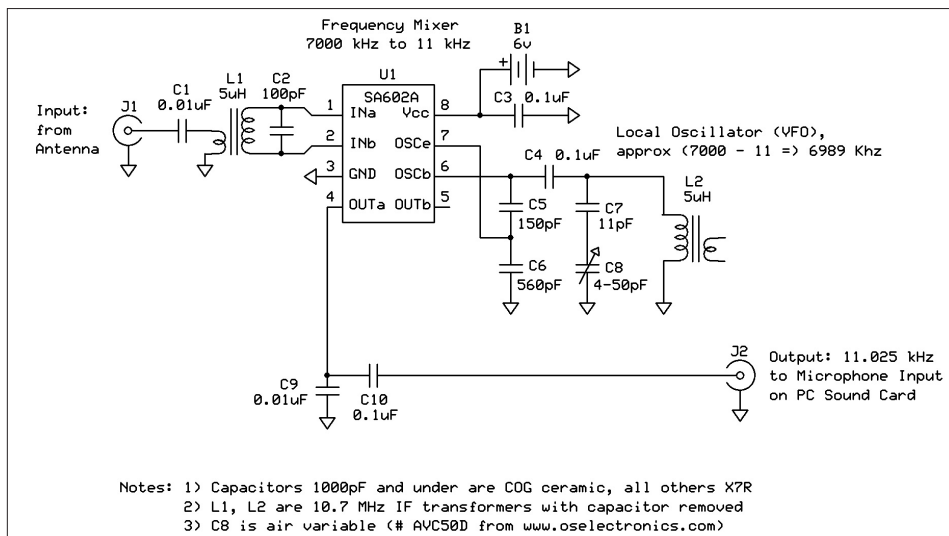


Figure 4: The schematic of the 7000 kHz to 11 kHz Receive Converter.



Parts List:

B1	4xAAA	DigiKey#	BC4AAAW-ND
C1	0.01uF	DigiKey#	BC1078CT-ND
C2	100pF	DigiKey#	BC1013CT-ND
C3	0.1uF	DigiKey#	BC1084CT-ND
C4	0.1uF	DigiKey#	BC1084CT-ND
C5	150pF	DigiKey#	BC1015CT-ND
C6	560pF	DigiKey#	BC1022CT-ND
C7	11pF	DigiKey#	490-3624-ND
C8	4-50pF	OSE#	AVC50D
C8	TermStrip	DigiKey#	WM15900-ND
C8	MountTape	Scotch#	114
C8	4-40x1/4"	DigiKey#	H142-ND
C8	Knob	Mouser#	450-2039-GRX
C9	0.01uF	DigiKey#	BC1078CT-ND
C10	0.1uF	DigiKey#	BC1084CT-ND
J1	TermStrip	DigiKey#	WM15900-ND
J1	Cable	RS#	278-964
J2	TermStrip	DigiKey#	WM15900-ND
J2	Cable	RS#	42-2387
L1	5uH	Mouser#	42IF124-RC
L2	5uH	Mouser#	42IF124-RC
U1	SA602A	DigiKey#	568-2089-5-ND

Tools:

Breadboard	DigiKey#	436-1046-ND
Rubber Feet	DigiKey#	SJ44140-ND

Suppliers:

DigiKey =	www.digikey.com
Mouser =	www.mouser.com
OSE =	www.oselectronics.com
Scotch =	www.scotchbrand.com
RS =	www.radioshack.com

Figure 5: The parts list for the Receive Converter.

to breadboard column J row 8, and its shield to column J row 11. And finally, install C9 and C10 to provide the output filter and DC blocking capacitor. The center conductor of the converter's output is at column A row 21, and its shield is at column A row 18. A Eurostyle terminal strip is shown connected to these points. Not shown, but attached to the other side of this strip, is a modified audio cable that plugs directly into the sound card's microphone input. To fabricate this, cut the plug off one end of a Radio Shack #42-2387, a 6-foot shielded audio cable ending in two 1/8-inch stereo phone plugs. Next, install a fresh #11 blade in the Xacto knife and place it on top of the cable, about 1 1/2 inches down from the cut end, with a block of wood underneath. Carefully move the knife back and forth rolling the cable underneath so as to cut about halfway through the cable's outer jacket all the way around. Gently bend the jacket back to examine and promote the depth of cut. Then, slit the jacket from here to the cable's cut end, cutting all the way through the jacket only as the end is approached. Now, use the needle nose pliers to pull the jacket apart being careful to separate the shield wires from the inside of the jacket. Unbraid the shield wires, twist them clockwise, and trim the resulting stranded wire to 3/4 inch. If available, use an ohmmeter to identify which of the two center wires is connected to the tip of the 1/8-inch phone plug at the other end. Otherwise, select the white wire, as it's

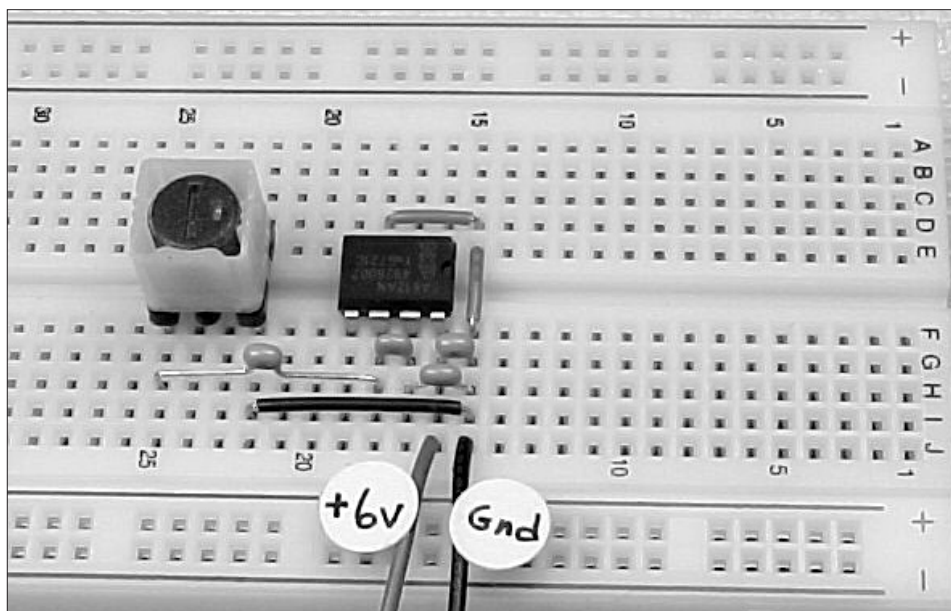


Figure 6: Building the Receive Converter, Stage 1.

most likely the right one. Trim this wire to 3/4 inch, strip 1/4 inch of insulation from it, and twist the exposed conductor wires together clockwise. Bend the unused center wire back against the cable's jacket, tape it down, and cover any exposed conductors with Scotch tape. Insert the prepared center wire and shield wire into the appropriate terminals of the Eurostyle strip and secure them. A second cable for the antenna input can be fabricated in a similar manner from a Radio Shack #278-964, a 6-foot length of RG-58 coaxial cable ending in two BNC male connectors. Coaxial connector adapters from Radio Shack, and elsewhere, may be used to adapt the BNC connector to whatever

is on the end of the transmission line from the antenna.

Trying out the Receive Converter for the First Time

Connect the antenna to the receive converter, plug its output cable into the sound card's microphone input, and power it up. Next, run the version of passthru.exe with the product detector software in Figure 2. Then, click Start > All programs > Accessories > Entertainment > Volume Control. Now, click Options, click Properties, select Playback, check both the Volume Control and Wave checkboxes, uncheck the other checkboxes, and click OK. Make sure the both the master volume control and wave input are not muted

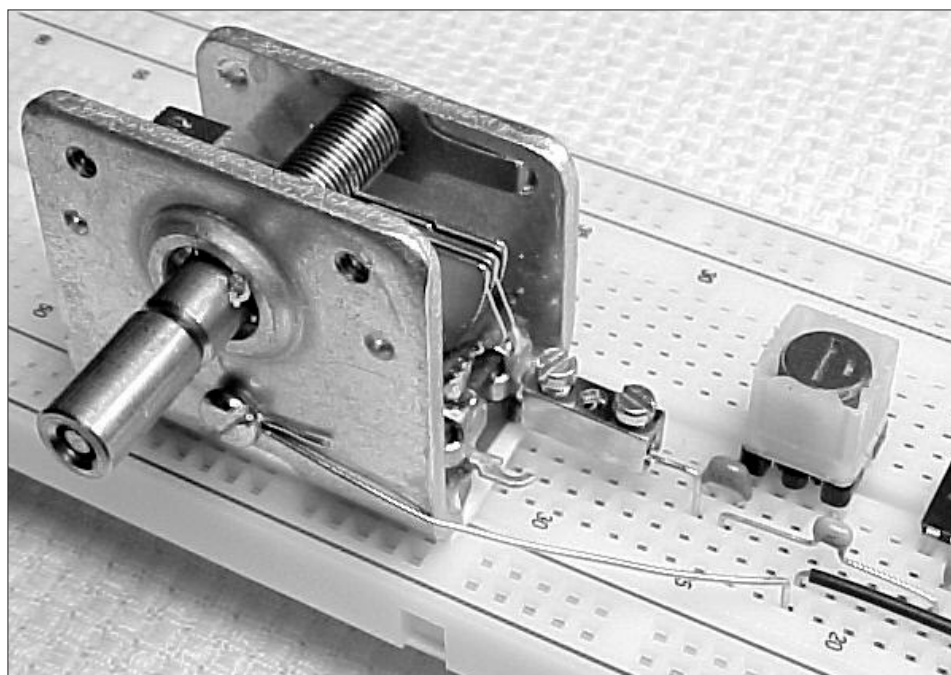


Figure 7: Building the Receive Converter, Stage 2.

and their slider controls are at maximum. Now, click Options, click Properties, select Recording, check the Microphone checkbox, and click OK. Then, make sure the microphone select box is checked and its slider is at maximum. Note that the microphone's slider control serves a role similar to that of an RF gain control. Set it as high as possible, but back it off as necessary to keep from overloading the sound card. Also, if there's an Advanced button, click it to access the Mic Boost which is needed for weaker signals. Finally, if the sound card's speakers have a volume control, turn it up to maximum to start. Now, gently turn L1's slotted core clockwise until it's down as far as it will go. Next, turn the core counter-clockwise up 1 turn. Then, tune C8 to find some signals. Select a moderately weak signal with no fading and slowly adjust L1 for the loudest audio. And lastly, turn off the PC's monitor, if necessary, to eliminate any radio interference from it.

If nothing is heard, plug the receive converter directly into a high-gain audio amplifier and speaker, such as a Radio Shack #277-1008. If nothing is still heard, look for problems with the receive converter and antenna. When signals are heard, plug the converter into the sound card's microphone input and run the original version of passthru.exe from Part 4. This replaces the analog audio amplifier with a similar digital audio system that will verify the sound card and PC are working. Ignore any 60 Hz hum. It's the presence of radio signals that's important.

As mentioned before, this nifty little receive converter does have some

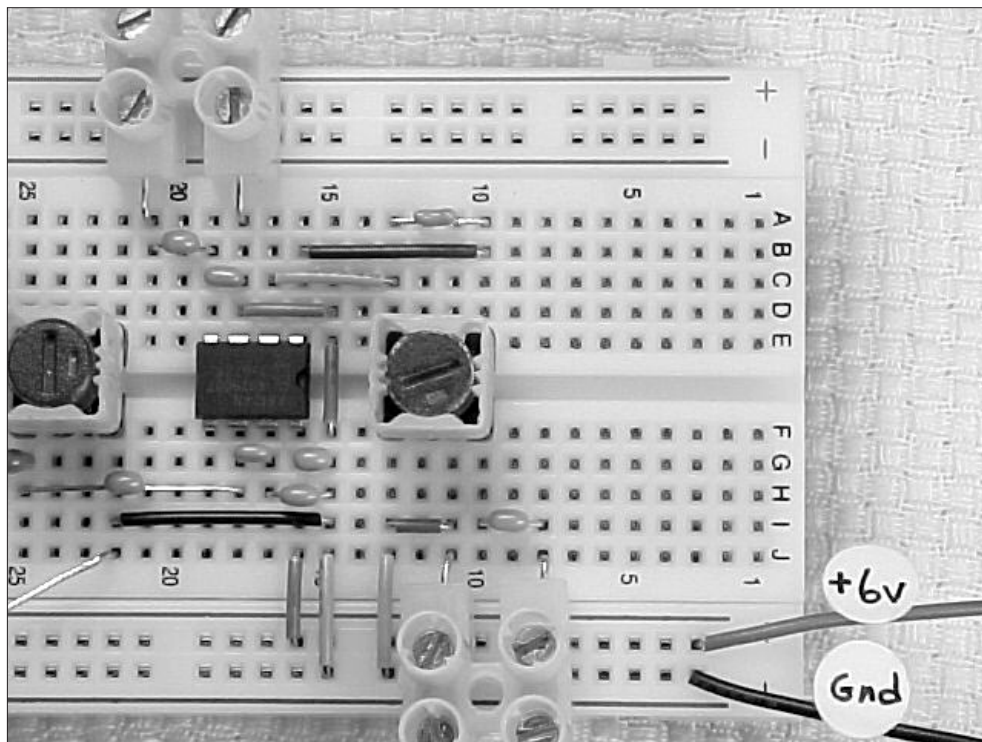


Figure 8: Building the Receive Converter, Stage 3.

In this case, it's practically impossible to filter out this undesired image over the tunable range of the converter, as it's only 22 kHz away from the desired signal. Another consequence of this is that a given signal will appear at two settings of C8 separated by 22 kHz. Note these characteristics when using the converter to better appreciate the improvement when this problem is addressed. The second biggest issue is the frequency stability of the local oscillator is not as good as it could be. To minimize this issue, locate the receive converter in a stable temperature environment with no drafts. For example, don't let the PC's cooling fan blow on it in any way and avoid breathing on it. Second, power it on and let it "warm up" for half an hour, or so. Third, raise it up from the surface it's on to minimize any interaction between the surface

required display resources may not be available. So passthru.exe shuts down and waits. Disabling these four occurrences of this function will reduce these interruptions. Then, to make the "Pgm debug" message go away, replace line 220 with the line in Figure 10.

And finally, if this is too much talk about 40 meters in a satellite radio journal, consider that a future project is to receive satellite VO-52's downlink with a Hamtronics CC-145 2 meter receive converter (www.hamtronics.com) modified to translate 145.900 MHz down to 10.7 MHz, followed by this simple SDR reworked to tune from 10.65 to 10.75 MHz. 📡

```
//SetDlgItemText(hwnd, IDC_TEXT1, TEXT("InBuf1---processed"));
```

Figure 9: Example of a line of C code that is "commented out".

performance issues. The most significant of these is that it has no image rejection. For example, to receive a signal at 7011 kHz, the local oscillator is set to $(7011 - 11) = 7000$ kHz. This is the $(f_1 - f_0)$ response of the frequency mixer as shown in Figure 1. However, the converter will simultaneously receive an "image" signal, if present, at $(7000 - 11) = 6989$ kHz. This is the mixer's $(f_0 - f_1)$ response.

material and the local oscillator. That's one reason for the tall rubber feet in the parts list.

And Finally

Changing focus back to the software, comment-out lines 255, 262, 269 and 276 in passthru.c. For example, line 255 should look like Figure 9. These lines contain the function SetDlgItemText(), which writes text to the PC's display. However, if Windows is busy opening programs, etc., the

```
SetDlgItemText(hwnd, IDC_TEXT1, TEXT(""));
```

Figure 10: Line 220 in passthru.c revised to eliminate the "Pgm debug" message.



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